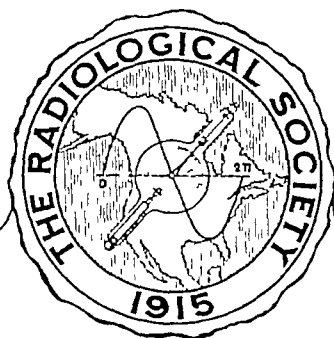




# RADIOLOGY

A MONTHLY JOURNAL DEVOTED  
TO CLINICAL RADIOLOGY AND  
ALLIED SCIENCES



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MARCH · 1934

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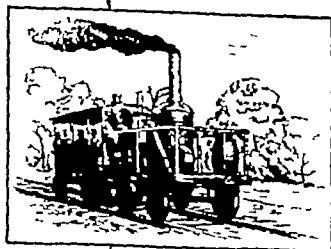
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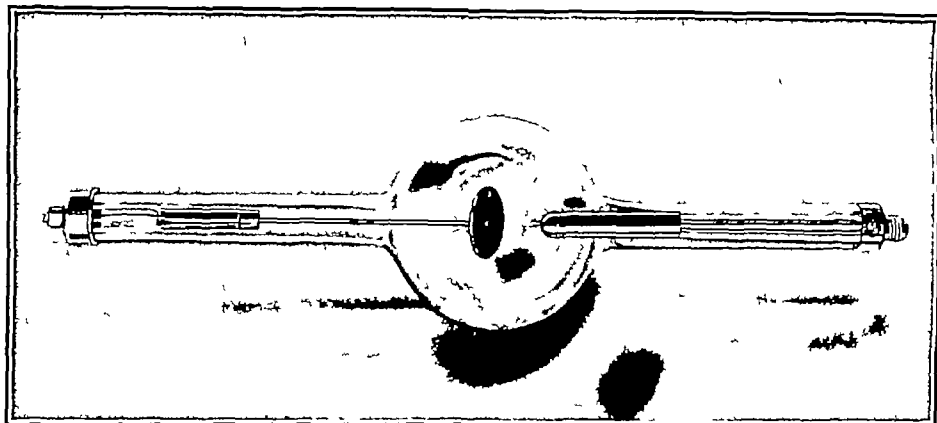
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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XXII

MARCH, 1934

No. 3

## A METHOD OF EXTERNAL IRRADIATION OF THE AXILLA<sup>1</sup>

By JAMES J. DUFFY, M.D., *Assistant Attending Surgeon and Assistant Radiotherapist, and*  
CHARLES DE FOREST LUCAS, M.D., *Fellow Memorial Hospital, New York City*

IRRADIATION of the axilla for metastatic carcinoma of the breast has been a routine procedure in many institutions since the acceptance, by the medical profession, of roentgen radiation as a means of treating malignant tumors.

Interstitial irradiation, by means of long needles containing radium element, and gold wires and seeds containing radon, has been used with varying success by a number of men. This method has not met with universal acceptance. However, practically all tumor clinics employ x-rays in the irradiation of the axilla for the treatment of metastatic breast carcinoma. Some treat the axilla only in inoperable cases, others use the treatment as an adjunct to surgery, either before or after operation, or both before and after operation.

It is not within the scope of this paper to discuss the indications for axillary irradiation, but an attempt is made to present a logical and effective method by which external radiation may be given. The problem here, as in most cases of external irradiation, is to deliver the largest dose possible to the tumor-bearing area, with the minimum amount of trauma to the skin and other vital structures within the field of radiation.

Various methods of axillary irradiation

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933.

have been employed at the Memorial Hospital. These methods may be defined, according to the number of ports employed, as follows:

(1) *Two Ports*—One port anterior, and one port posterior, employing large fields up to 20 × 20 centimeters.

(2) *Three Ports*—The anterior and posterior ports as above, but smaller, with an additional port directed into the axilla, with the arm in abduction.

(3) *Four Ports*—Same as the three-port, with an additional superior port to the supraclavicular region, directed downward toward the axilla.

(4) *Five Ports*—The above four ports, plus an extra port, directed toward the axilla through the lateral surface of the adducted arm.

The five-port method was soon discarded because it was found that, by irradiating through the lateral port with the arm adducted, a fold of the skin covering the axilla lay in the field of irradiation, causing this portion of the skin to receive an additional dose of radiation on the area already irradiated. This should be avoided, as the skin of the axilla is especially sensitive to radiation trauma because of constant friction, and moisture from perspiration.

In an attempt to discover the method which would give the greatest dosage of radiation to the axilla, measurements of

the axillæ were made on 50 cases of carcinoma of the breast, the unaffected side being measured. From these measurements, the size of the ports and the delivered dosage were computed. These measurements were made as follows:

body plane drawn through the point of the anteroposterior measurement, represents the approximate center of the axilla.

(4) Vertical, from the central axillary point to the shoulder surface.

(5) The estimated thickness of the

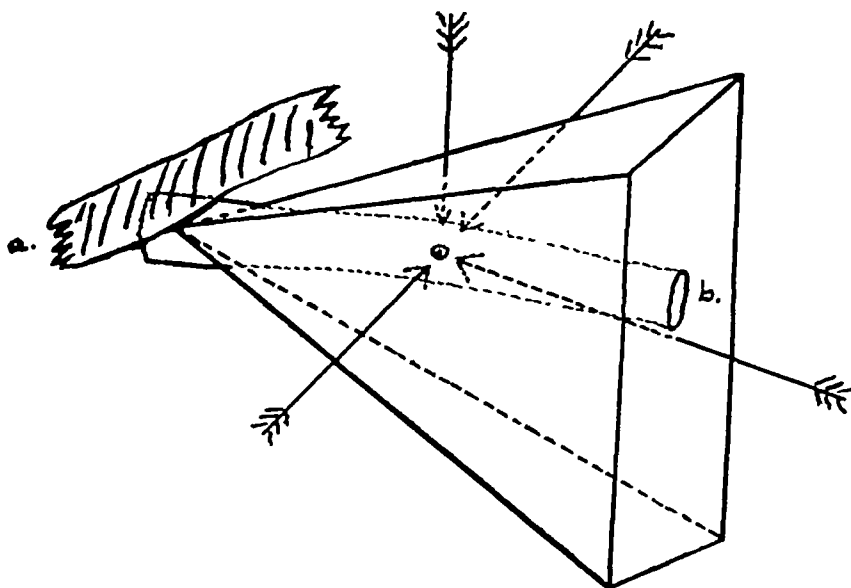


Fig 1. A schematic representation of the axilla. The arrows indicate the direction of the beam for the different ports: (a) is the clavicle, (b) the axillary vein, and (c) the mid-point of the axilla.

(1) From the lateral surface of the arm to the axillary fold (this varied but little, being 8 cm. in most cases).

(2) From the axillary fold to the sterno-clavicular junction. (This gives the transverse dimension of the axilla, as the axillary fold denotes the lateral surface of the axilla, and the apex is at the point where the large vessels dip under the clavicle, at the junction of its middle and medial thirds.)

(3) Anteroposterior at a point one-half the distance between the axillary fold and the apex of the axilla, on a line from the apex to the insertion of pectoralis majoris muscle, a line which represents the course of the great vessels. The point of intersection of the lumen of the axillary vein, and a line perpendicular to the transverse

panniculus adiposus, overlying the skin of the axilla. This in each case was estimated to be about the same at 1.5 cm., and varies with adduction and abduction of the arm. With the arm in extreme abduction, the mid-point of the axilla lies about 3 cm. from the skin, a measurement which varies little with the adiposity of the patient.

The mean of the axillary measurements of the 50 cases was taken, and a cadaver obtained with measurements as nearly as possible identical with the average of the cases already measured. A careful dissection was made of the axilla, removing all of the axillary contents with the exception of the large blood vessels and nerves. With the arm in adduction, the dissected cavity was filled with plaster,

the resulting cast representing the axillary contents. The cast was found to have the approximate shape of a rectangular pyramid, with the axillary skin for its base (Fig 1).

As the route of metastasis follows the lymphatics accompanying the axillary vein, the center of the tumor-bearing area is approximately the center of the axilla described above. This is the point on which the centers of the beams of radiation are directed. Measuring from the various skin surfaces to this point, the measurements in Table I were obtained.

TABLE I—SHOWING DOSAGE OF RADIATION DELIVERED TO AXILLA THROUGH VARIOUS PORTS

Portal	Distance to mid axilla	Dimension of portal and percentage S E D to axilla
Anterior	3.0 cm	10 × 10-85% 20 × 20-90%
Posterior	10.0 cm	10 × 10-35% 20 × 20-40%
Direct arm abducted	3.0 cm	10 × 8-80%
Superior	5.5 cm	8 × 6-60%

The first axillary measurement is the thickness of the arm to the central point of the axilla, a fact which shows that this distance to the axilla, through a lateral port with the arm in adduction, is too great for an effective dose to be delivered into the axilla, even if the over-radiation of the axillary skin is disregarded. The second measurement, from the axillary fold to the sternoclavicular joint, varies with the size of the thorax and was used to aid in the determination of the size of the mean average axilla, and in the selection of an identical cadaver measurement. The anteroposterior measurements show that the center of the axilla lies only 3 cm from the skin anteriorly, but 10 cm posteriorly. The vertical distance averages 5.5 cm, and the lateral distance, with arm abducted, 3 centimeters. Thus, the axilla is nearer the superior surface of the thorax than it is generally thought to be.

At the same time the axillary measurements were being made on the 50 cases of breast carcinoma, the determination of the size of the skin ports was done, the desire being to use the largest ports possible without overlapping on the skin.

This was accomplished by cutting from cardboard a number of rectangles and squares of various dimensions, and placing them on the skin so as to cover the largest areas possible over each port of entry, without overlapping of the radiation beams. Table I shows the size of ports adaptable to the average case. The 20 × 20 cm ports were previously used when only two ports were employed, and included both the supraclavicular and anterior axillary regions. With small ports, a separate beam of radiation is directed to the center of the supraclavicular region.

A model of the axilla and of the large vessels was made and mounted. In Figure 2, the size of the ports, with their relative distances to the mid-axillary point, are shown, all ports being large enough to cover the entire axilla. The margins of the axilla, being in a peripheral portion of the radiation beam, receive somewhat less radiation than the central point, which receives more scattered rays. In this model, the direct port is not shown, as the cast was made with the arm in adduction. The model of the axilla would be of an entirely different shape if the cast were made with the arm in abduction. With the size of the ports and the distance to a given point being known, it is a simple matter to determine the dosage delivered. Table II is a depth dosage chart showing the measurements.

TABLE II—SHOWING DEPTH DOSAGE OF VARIOUS SKIN AREAS, 100 PER CENT DOSES BEING DELIVERED TO THE SKIN SURFACE, 200 K V AT 50 CM DISTANCE FILTER OF 0.5 MM CU AND 2.5 MM AL

Depth (Cm)	Square Centimeters on Skin						
	25	50	100	150	200	300	400
	Percentages of S E D Delivered						
0	100	100	100	100	100	100	100
1	98	99	100	100	100	101	101
2	88	92	94	94	95	97	96
3	78	81	85	87	88	89	89
4	66	70	75	78	79	80	81
5	55	62	67	70	72	74	76
7	40	46	51	54	56	58	59
10	24	28	33	36	37	40	41
12	18	21	25	27	28	30	31
15	11	14	17	18	20	22	23



the axillæ were made on 50 cases of carcinoma of the breast, the unaffected side being measured. From these measurements, the size of the ports and the delivered dosage were computed. These measurements were made as follows:

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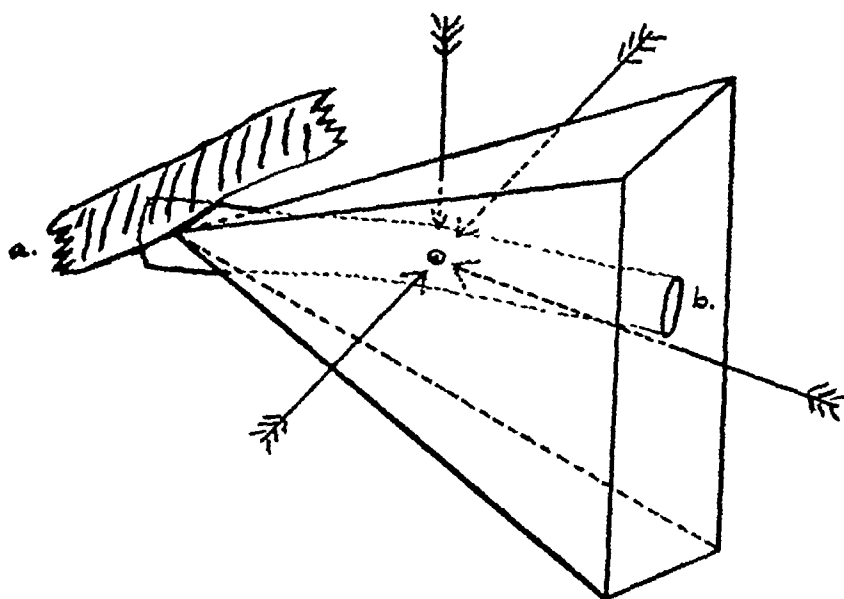


Fig. 1. A schematic representation of the axilla. The arrows indicate the direction of the beam for the different ports: (a) is the clavicle, (b) the axillary vein, and (c) the mid-point of the axilla.

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TABLE III—COMPARISON OF TISSUE DOSAGE IN CENTRAL POINT OF AXILLA, WITH VARIOUS NUMBERS OF PORTALS, AND DIFFERENT SIZES OF PORTS

Ports	Size	Total dosage
Anterior } 2 ports	20 × 20	90%
Posterior }	20 × 20	40%
		130%
Anterior } 3 ports	10 × 10	85%
Posterior }	10 × 10	35%
Direct }	10 × 8	80%
		200%
Anterior } 4 ports	10 × 10	85%
Posterior }	10 × 10	35%
Direct }	10 × 8	80%
Superior }	8 × 6	60%
		260%

and one posterior, approximately 130 per cent T E D will be delivered to the mid-portion of the axilla. The addition of the direct port necessitates the reduction of the size of the anterior and posterior ports, as the larger ports include the axillary skin in the cross-fire. When the size of these two ports is reduced to 10 × 10 cm, and the additional port of 10 × 8 cm is added directly into the axilla, 200 per cent T E D is delivered to the mid-portion of the axilla (Table III). When a beam of radiation is directed toward the axilla through an 8 × 6 superior port, 60 per cent of the skin radiation reaches the central point of the axilla, making a total of 260 per cent of a skin erythema in the central point.

These calibrations are made on the basis of 100 per cent S E D being delivered to the skin over each port. If four ports are used, the additional scattered radiation delivered to the various skin surfaces is appreciable. This is not important because of the recuperation of the skin during the twenty-four-hour interval, at which interval the successive treatments are given. Moreover, the additional radiation from the opposing portal is only 15 per cent, and this amount is well within the margin of safety.

The four-port method, while delivering more radiation to the axilla, necessitates

care in the directing of the radiation beam, because it is difficult to place the patient in a convenient position for the superior port. We feel, however, that the four-port method has definite advantages over those previously used at the Memorial Hospital.

The multiple-port irradiation of the axilla is more applicable to divided dose technic than it is to the massive-dose method, because, in the former technic, the skin has four days to recuperate, while the tumor is being irradiated each day.

#### SUMMARY

1 An attempt is made to determine a method by which the greatest amount of radiation may be delivered to the center of the axilla, with minimum skin damage.

2 There are several combinations for the convergence of multiple radiation beams on the center of the axilla.

3 Measurements of many axillae were made to determine the average distance to the center of the axilla from several possible ports. These distances are given.

4 The tissue dosage, in the center of the axilla from the several ports, is given, and the dosage from the combinations of converging beams totalled.

5 It is found that the four-port method is the most practical.

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These doses were measured in a water phantom, with a 200 K V x-ray machine at a target distance of 50 cm, and with a sufficient to cause an appreciable reddening, and tanning of the skin from three to four weeks after exposure in 80 per cent of

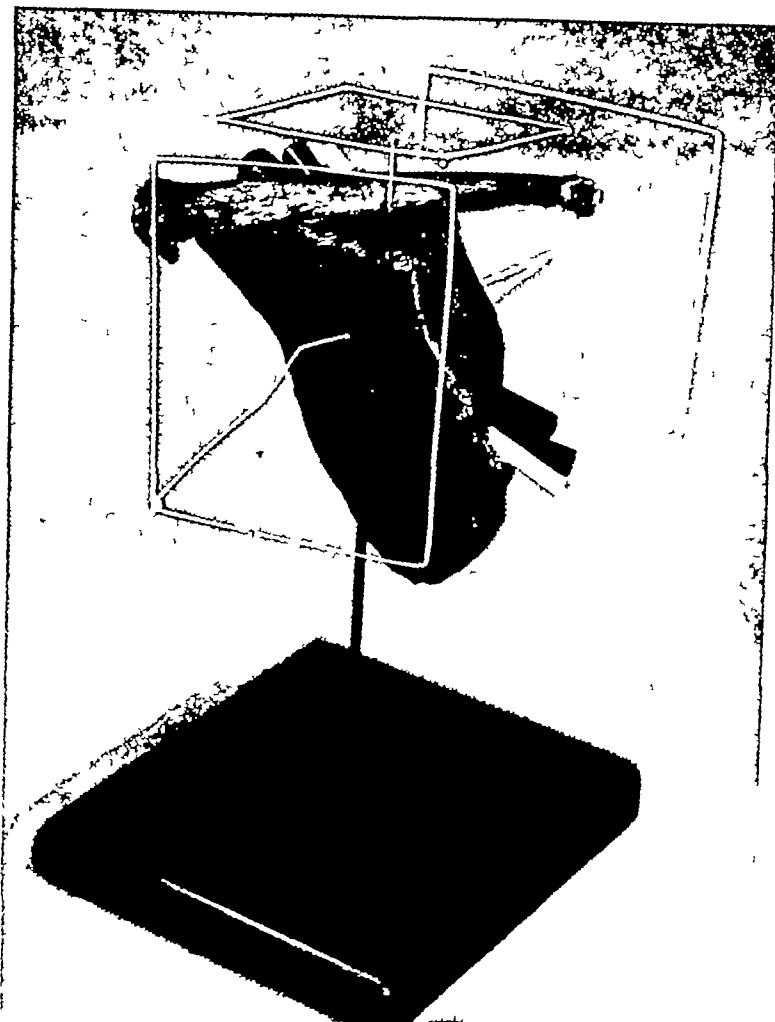


Fig 2 Model of avulla, showing relative size and position of anterior posterior, and superior skin ports

filter of 0.5 mm Cu and 2.5 mm Al. The measurements were made by Qumby and, according to recent comparisons, vary only slightly from readings made on a cadaver and on living tissues. The unit of measurement employed is the skin threshold erythema dose. This unit of measurement for external irradiation was developed by Qumby, Dean, and others, and may be defined as the amount of radiation

the treated cases, yet will not cause any noticeable change in 20 per cent. This threshold erythema dose is about 525 roentgens when given on the 200 K V machine at 50 cm distance, with a filter of 0.5 mm Cu and 2.5 mm Al, on a  $10 \times 10$  cm port, to the external surface of the lower arm.

It will be noted in Table I that if two  $20 \times 20$  cm ports are used, one anterior

the symptom-complex is caused by the pathology of the skeleton, a group which may rightly be called osteodystrophies, since in the ultimate analysis these conditions in the skeleton are caused by abnormalities in the endocellular metabolism. The most common of this group are osteomalacia, osteitis fibrosa (von Recklinghausen), and osteitis deformans (Paget's), all characterized by a slowly progressing disturbance of the structure of all, or the major part, of the skeleton. A picture of complete destruction of the bone and replacement by soft tissue dominates in osteomalacia. Transformation of normal bone into fibrous calcified connective tissue, which replaces the compact and cancellous bone as well as the bone marrow, is characteristic of osteitis fibrosa and osteitis deformans.

Frequently, however, both processes are present side by side and it may be impossible to differentiate pathologically osteomalacia from osteitis fibrosa, and just as difficult to distinguish osteitis fibrosa from osteitis deformans. In a general way, the former is accompanied more frequently by formation of large cysts and so-called giant-cell tumors, and osteitis deformans by new bone formation, but both cyst formation and osteoplasia are present in the two diseases.

The etiology of the osteodystrophies is quite unknown. Lang (3), Jaffe (4) and others have succeeded recently in producing similar conditions in the bones of animals by removal of the parathyroids, thus producing experimental proof of the intimate relationship between abnormalities in endocrine functions and the disturbances in the skeleton. However, the nature of this relationship is not clear. The assumption that general acidity of the organism and lack of calcium in the circulation are followed by an absorption of the calcium from the skeleton is too crude a conception of endocellular metabolism and does not account for the occurrence of localized osteitis fibrosa or deformans in which many parts of the skeleton remain unaffected. In the case reported in this

presentation the calcium content in the blood was normal. Moreover, the function of the parathyroids and the abnormalities of the calcium metabolism do not represent the only, or even the main, causes of either osteoporosis or osteoplasia.

In order to get a clearer insight into the causation of osteodystrophies it is necessary to understand the mechanism of the pathologic transformation of the skeleton—its pathogenesis.

The osteodystrophies are chronic conditions—they last for years and usually do not cause any general disturbances in the organism until after the pathologic process is completely established, and often not even then. Therefore, the pathologist or the radiologist rarely gets the opportunity to observe the mechanism of the formation of these abnormalities from the incipency to the final development of the condition. The case presented here offered such an opportunity for the study of the early stages of formation of osteitis deformans.

#### CASE REPORT

J. A., male, 63 years old, came to the writer on March 9, 1932, with a history of having sustained, four days previously, a fracture of the left arm, caused by a fall on a slippery floor while dancing. The patient stated that, two years before, he had sustained a fracture of the left scapula. Otherwise he had no complaints and gave no history of any previous disease. He is active as a clerk in the Post Office Department.

Examination showed the fractured arm in a temporary splint and, on superficial inspection, no other abnormalities. A roentgenogram of the arm in the splint showed a fracture in the lower third of the humerus, while the head of the humerus and the scapula showed irregular areas of rarefaction interspersed with strands of new bone formation (Fig. 1). A provisional diagnosis of osteitis deformans was made. The temporary splint was removed and roentgenograms of the arm taken. At the lower third of the shaft of

# A COMPARATIVE ANALYSIS BETWEEN THE PATHOGENESIS OF OSTEODYSTROPHIES AND BONE TUMORS<sup>1</sup>

By ISAAC LEVIN, M D, *New York City*

THE proper classification as well as the correct diagnosis and prognosis of tumors of the bone represent the most difficult chapter of oncology. Tumors of the bone may be indistinguishable morphologically and roentgenologically from inflammatory, metabolic, or endocrine diseases of the bone. Primary sarcoma, metastatic carcinoma, osteomyelitis, syphilis of the bone, and the various types of osteodystrophies may present pictures so similar that a differential diagnosis becomes impossible. Von Recklinghausen (1), in his classical study in 1891 on the pathology of the disease of the skeleton which bears his name, came to the conclusion that this disease presents close analogies with Paget's disease of the skeleton and osteomalacia on one hand, and with metastatic carcinoma of the skeleton on the other.

The reason for these complexities must be sought for in the structure and function of the normal bone. Bone tissue, though apparently inert and serving, with fibrous tissue, as the groundwork for the parenchymatous organs, is in reality endowed with finely designed functions. On one hand, it acts as a rigid protecting receptacle for the central nervous system and the bone marrow—a blood-forming organ. On the other hand, it acts as the rigid framework for the whole organism, supports and guides the nerve-muscle apparatus and the joints, and thus makes correct locomotion, the obtaining of food, and self-protection possible. These functions require truly mathematical precision. It is remarkable how well deformities caused by poorly set fractures or by diseases, like rickets, may be corrected both as regards the function and the shape of the bone. To understand this phenomenon, not only

the ontology but the phylogeny of the vertebrates must be taken into consideration.

In view of these functional requirements, any insult which the bone receives from the outside or inside of the organism, any destruction of bone or loss of continuity of the bone tissue, is followed by a very active reparative or reactive process accompanied by new bone formation. The more efficient this reparative process, the more extensive the new bone formation (the osteoplasia), the more difficult is it to differentiate the underlying cause. The new osteoplasia dominates the picture.

These difficulties become particularly evident when the necessity arises to differentiate between the osteoplastic types of the osteodystrophies and the osteoplastic skeletal metastases in carcinoma. While the pathogenesis of the two conditions must be entirely different, the resultant condition is frequently identical.

The purest type of rapidly forming new osteoplasia after a loss of continuity is the formation of a callus in a traumatic fracture in the case of a normal individual. A comparative study of the healing of various types of abnormal fractures may help in the understanding of the mechanism of the various reactive processes of bone.

A serial roentgen study of a traumatic fracture of the humerus in a patient suffering from osteitis deformans (Paget's) has shown most unusual healing reactions. It seemed of value, in order to assist in the elucidation of the pathogenesis of bone tumors and osteodystrophies, to report the case and compare the findings with the results of the previous roentgenologic and pathologic (2) studies of the early stages of metastatic carcinoma of the bone.

## OSTEODYSTROPHIES

There is a group of diseases of nutrition and of the endocrine glands in which

<sup>1</sup> Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28-Dec. 1, 1932.

normalities Lungs and heart showed no abnormality Blood pressure was 130/70, pulse rate rapid and easily excitable (100 to 140 a minute), but there was no exophthalmos and no enlargement of the thyroid

At the same time an area of osteoporosis appeared in the lower segment (Fig 8)

Six weeks later, the area of osteoporosis had increased (Fig 9)

Six months after the cast had been applied



Fig 4 Roentgenogram of the pelvis Shows fully developed osteitis deformans

Basal metabolism was plus 14 No abnormalities were found in the gastro-intestinal nor in the genito-urinary tracts Wassermann test was negative

Blood chemistry showed sugar 132 mgm , non-protein 30.2 mgm , uric acid 4.4 mgm , calcium 12 mgm Blood morphology showed erythrocytes 4,550,000, leukocytes, 8,250, polymorphonuclears 77 per cent, lymphocytes 23 per cent, hemoglobin 96 per cent color index 1.0 This clinical analysis showed no organic disease, with the possible exception of hyperthyroidism

One week later a roentgenogram of the left humerus showed the fractured ends in the same position and no evidence of callus formation (Fig 7)

Two weeks later a roentgenogram showed no change in the position of the fractured ends and a beginning of a callus formation

a roentgenogram showed an extensive callus, and both the callus itself and the shaft of the humerus above and below it showed an advanced state of osteitis deformans (Fig 10) It is significant that during the same time the condition in both femora had not advanced The cast has been removed and the result appears functionally perfect The bone is solid, the arm is not foreshortened, and, notwithstanding the slight atrophy of the muscles, the limb functions normally

At present the humerus and its callus present a perfect picture of osteitis deformans but the patient appears to have a normal arm clinically

The most unusual phenomenon observed in the course of the healing of the traumatic fracture in this case, which distinguishes it both from the healing of a



Fig 1 (above) Roentgenogram of the left arm in the provisional splint. Shows osteitis of the head of humerus and scapula.

Fig 2 (below) Roentgenogram of left humerus without splint. Shows the fracture and little abnormality in the bone.

the humerus there was noted a complete oblique fracture, with displacement of the



Fig 3 Roentgenogram of left humerus with splint. Shows the improved position of the fragments.

lower end upward and forward and of the upper end downward and backward. Both the middle and lower thirds of the humerus showed little evidence of the osteitis noted in the head of the humerus (Fig 2). In view of the diagnosis of osteitis deformans no attempt was made at complete reduction. A better apposition of the broken fragments was obtained and a plaster cast applied (Fig 3).

Roentgenograms were taken of the left arm in the cast and also of the skull, pelvis, and both femora. The skull and pelvis showed advanced stages of osteitis deformans. The femora appeared thickened and bent, but otherwise showed an earlier stage of the disease (Figs 4, 5, and 6).

A clinical examination of the patient was then made, showing, on inspection, dry skin, little subcutaneous fat, prominent subcutaneous arteries, and no other ab-

normalities. Lungs and heart showed no abnormality. Blood pressure was 130, 70; pulse rate rapid and easily excitable (100 to 140 a minute) but there was no exophthalmos and no enlargement of the thyroid

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Fig 5 Roentgenogram of the skull Shows fully developed osteitis deformans

traumatic fracture of a normal individual and from the healing of a pathologic fracture within a malignant tumor of bone, is the following. A rigid and perfectly functioning callus was formed. At the same time, within the callus itself and in the shaft of the humerus both above and below the callus, were noted numerous areas of bone absorption (minute cysts). In other words, the callus formation was accompanied by progressive local development of osteitis deformans. A normal callus in a traumatic fracture of a normal individual shows only new bone formation and no absorption of the newly formed bone. Rarefaction of bone or cyst formation occurring in a traumatic fracture of a normal individual would indicate (Fig 8) the formation of a sarcoma within the callus.

The development of a sarcoma within a callus is observed frequently, though it is usually impossible to ascertain whether or

not a minute, indiscernible sarcoma was present when the fracture occurred.

A callus produced as a result of a pathologic fracture in skeletal metastasis of carcinoma may appear on superficial analysis similar to the callus described above in an individual suffering from osteitis deformans (Paget's). The important difference, however, between these two conditions is the following. The fracture healed perfectly (in the case described above) and at the same time the osteitis in the humerus progressed and became more advanced. A pathologic fracture, on the other hand, heals only when the growth of the carcinoma is arrested. A progress of the carcinoma is followed either by non-healing of the fracture or the occurrence of a new fracture. The mechanism of the healing of the fracture in the reported case of Paget's is, therefore, the best proof of the correctness of the diagnosis.

#### METASTATIC CARCINOMA OF THE BONE

In order to understand the basic difference in the pathogenesis of osteodystrophies and bone tumors it is essential to study the mechanism of the formation of the morphologic changes which take place in the bone in the course of the development of these two conditions. A generalized osteoplastic metastatic carcinomatosis of the skeleton, particularly if due to primary carcinoma of the prostate or thyroid, cannot be differentiated either microscopically or roentgenologically from osteitis deformans. A microscopic study of skeletal metastases of carcinoma may help in the understanding of the reason for this similarity.

The metastasis begins its development within the marrow, and, when the group of cancer cells is small, the surrounding bone marrow appears quite normal. Von Recklinghausen claims that the development of the metastasis is preceded by a hyperemia and hemostasis, due to obstruction of the capillaries by the tumor emboli. In the specimens studied by the

writer, hemorrhage and hyperemia were noted frequently around large tumor masses, but not around minute metastatic nodules. In the latter instance no morphologic abnormality could be found in the bone marrow.

the changes in the normal tissue surrounding the metastasis consist in destruction of the compact bone. These two separate conditions can be easily differentiated on the gross inspection of skeletal metastases. However, the microscopic study of the



Fig 6    Roentgenogram of both femora    Shows an early stage of osteitis deformans

As the tumor nodule increases in size it approaches and invades the compact osseous tissue or the compact osseous partitions of the cancellous bone. Then there begin to appear the characteristic changes in the bone tissue. There are two classes of skeletal metastases of carcinoma: osteoplastic, in which extensive new bone formation takes place around the metastatic tumor, and osteoporotic, in which

cases analyzed by the writer showed that both conditions were generally present side by side. The differences in the gross appearance are due to the fact that in one case osteosclerosis, or new bone formation, predominates, while in another osteoporosis, or the destruction of the old bone, is mainly in evidence.

The mechanism of bone destruction in metastasis of carcinoma differs from that



Fig 7 Roentgenogram of left humerus one week later. No evidence of callus formation.



Fig 8 Roentgenogram of left humerus two weeks later. Beginning of callus formation and beginning of osteoporosis.

observed in osteodystrophy. Von Recklinghausen first made the observation that the large polynuclear osteoclasts, which destroy the bone in osteoporosis, are very seldom found in the lacunæ of the bone surrounding a growing metastasis of carcinoma, a fact which has been confirmed by most of the subsequent investigators. In view of the absence of the large osteoclasts, von Recklinghausen presumed that a softening takes place in this bone, due to the removal of the inorganic salts and a subsequent absorption of the tissues without the aid of any cells, a condition similar to the one found in osteomalacia. Apolant (5), Erbsloeh (6), and Askanazy (7) are also of the opinion that osteoporosis in skeletal carcinoma may take place without the aid of special cells. On the other hand, Goetsch (8) believes that the cancer cells frequently found close to the walls of the lacunæ are special osteoclasts derived from the cancer stroma. In the specimens studied by the writer, both cancer cells and the small connective tissue stroma cells

were found in immediate apposition to the walls of the lacunæ. The cancer cells were so frequently the only cellular elements within the lacunæ of the bone that it seems feasible to maintain that cancer cells may act as direct osteoclasts. The impression gained by the writer is that the small stroma cells only subsequently invade between the bone and the cancer cells. However, even if it be admitted that the stroma cells may act as osteoclasts, it is apparent that the tumor itself, by the aid of its formed elements, may destroy the bone, and then grow by occupying the space so formed.

The mechanism of the new bone formation as observed by the writer is as follows. At first, collagen fibrils are formed in abundance from the old bone. These fibrils gradually unite in thick bundles and subsequently form new bone tissue. The latter is clearly formed from the constituent parts of the old bone. On the other hand, as stated above, the writer did not observe any hyperemia, inflammation, or any other abnormality of the



Fig 9 Roentgenogram of left humerus six weeks later Increase of osteoporosis

bone marrow at the beginning of the development of the metastasis. Furthermore, necrosis of the bone was not found in any of the specimens examined. It must be concluded that some unknown factor derived from the cancer cells acts on the old bone tissue and stimulates its proliferation.

Thus two processes always take place side by side in skeletal metastases. On the one hand, the tumor destroys the normal bone tissue, on the other hand, the remaining osseous tissue proliferates and creates new bone, the latter most probably being an attempt at self-defense. In the microscopic field in which this osteoplasia is shown there is frequently no evidence of any cancer cells and the microscopic picture cannot be differentiated from osteitis deformans (Fig 10).

#### SUMMARY AND CONCLUSIONS

As was stated above, osteitis fibrosa and deformans appear to be morphologically and roentgenologically similar to osteoplastic metastatic carcinoma of the



Fig 10 Roentgenogram of left humerus six months later. Both the callus and the rest of the humerus show extensive osteitis deformans.

skeleton. There must also be, therefore, some similarity in the mechanism of the formation of the two conditions.

Osteitis fibrosa and osteitis deformans are comparatively rare conditions, the same being true of skeletal metastasis in carcinoma. Only 2.5 per cent of all cases of carcinoma of the stomach and 3 per cent of all cases of carcinoma of the uterus show metastases in the bones. It is significant that the types of carcinoma which most frequently develop metastases in the bones are carcinoma of the breast, of the prostate, and of the thyroid, *i.e.*, organs with active endocellular metabolism and endocrine functions. Moreover, even within these groups may be observed remarkable differences in development. In carcinoma of the prostate, the greatest number show extensive osteoplasia and the patients may continue to live even for years, with a well functioning skeleton. In carcinoma of the thyroid, the predomi-

nance of osteoplasia or osteoporosis is encountered with about equal frequency. On the other hand, in carcinoma of the breast, cases with osteoporosis are more frequently observed, and even a beginning of osteoplasia soon changes into osteoporosis.

In order to obtain a clearer conception of the relationship of these two phases in the development of skeletal metastases, as well as of osteodystrophies, it is necessary to analyze them separately.

The destruction of the normal bone tissue (osteoporosis) in skeletal metastasis is a purely local process and, as stated above, must be a direct function of the group of cancer cells transported to the bone. This function is most probably chemical, in accordance with von Recklinghausen's conception, and the resultant change in the bone, as he thought, is analogous to the condition found in osteomalacia. Probably not all types of cancer cells possess this capacity and many emboli of cancer cells which enter the bone marrow do not destroy the bone but are themselves destroyed by the normal tissue of the bone. The difference between the osteoporosis in carcinoma and in osteodystrophy consists in the fact that in the latter condition the cells which act on the bone do it at a distance and may represent the function of the parathyroids or other endocrine glands.

The new bone formation (osteoplasia) is undoubtedly, as stated above, an attempt at self-defense, a reactive or reparative process, and the mechanism of its formation is identical in all types of bone tumors or osteodystrophies.

The reason for the prominence of osteoplasia in some forms of osteodystrophies and tumors of the bone and its absence in others must be looked for in the differences of the function of the endocellular metabolism, whether it concerns endocrine

action, nutritional deficiency, or local action of cancer cells. One type of cancer cells or of endocrine organs may predominate in its destruction of the bone over the reparative power of the latter, while in other types of cells the reparative function of the bone tissue predominates. It is interesting to note in this connection that, in a general way, osteoporosis (rachitic, carcinoma of the breast) prevails in the young and osteoplasia (Paget's disease, carcinoma of the prostate) predominates in old age. This coincides with the fact that, during senescence, many types of parenchymatous tissues are replaced by fibrous connective tissue. Scirrhus carcinoma, in which the fibrous stroma predominates, is also a disease of old age.

A fully developed generalized case of Paget's is usually easy to diagnose. However, there are many cases reported without any pathology in the skull or involving only a few bones and even only one bone (9). A final diagnosis of Paget's should not be made until the possibility of primary malignancy elsewhere is excluded. In the case reported in this paper the mechanism of the healing of the traumatic fracture established the diagnosis of Paget's, though the patient did not present a classical picture of the disease.

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# ROENTGEN TREATMENT OF HYPERTHYROIDISM<sup>1</sup>

By THOMAS A GROOVER, M D , and ARTHUR C CHRISTIE, M D , *Washington, D C*

From the Radiological Clinic of Drs Groover, Christie, and Merritt

IN 1929 we reviewed all of our cases of hyperthyroidism, covering the period from 1917 to 1927, inclusive, and published a statistical analysis of 305 cases showing the results of treatment by roentgen irradiation (1). We will in this paper show the results of treatment of 252 additional cases, covering the period from 1928 to 1931, inclusive. Some of the statistical details embodied in the previous publication will be omitted from this report in order that other aspects of the subject may be more fully discussed.

It is our belief that statistics, as usually compiled for evaluating remedial measures in disease, are often accorded a degree of importance which they do not merit. Certainly this is true if mere weight of numbers is given primary consideration. Particularly in a disease such as hyperthyroidism in which there are so many collateral and complicating factors, both psychic and somatic, a mere tabulation of results following this or that method of treatment necessarily gives but an imperfect idea of the individual case. In one case an associated vascular hypertension or myocardial disease may render the interpretation of results exceedingly perplexing, and in another extrinsic circumstances such as the economic status of the patient or the personality and resourcefulness of the physician may be factors which determine success or failure of treatment. A careful analysis of fifty unselected cases, therefore, would be more illuminating than the compilation of five thousand cases which did not take these collateral factors into account.

Nevertheless, the latter method of approach has its value, and if it does nothing more, it gives some indication of the popularity of given remedial measures in par-

ticular communities, and affords a means of comparing the results of one method of treatment with another. Although it has been known for many years that irradiation is a comparatively satisfactory method of treating hyperthyroidism it is only recently that sufficient data in comparable form have been accumulated to parallel that relating to its surgical treatment.

There is far more to the treatment of hyperthyroidism than either irradiation or surgery connotes. Its successful management involves the management of a human being and not merely the treatment of a disease by a rule-of-thumb technic. Unless the radiologist is prepared to assume, and, in fact, does assume, that responsibility, he will have more than his share of unsatisfactory results. The fact that the radiologist has to a large extent been regarded as a dispenser of a remedy rather than as a clinician and consultant has delayed deserved recognition of irradiation as an effective method of treatment.

We have assumed such responsibilities in our own work for many years with, in the main, harmonious co-operation of internists who refer the majority of our cases to us. We record our own histories, make our own examinations, do our own basal metabolisms, and either have full responsibility for the general management of the case or share in it with the referring physician. Doubtless other radiologists who treat a considerable number of cases of hyperthyroidism pursue a similar policy, and we would not consider it worthy of mention but for the gratuitous assumption on the part of critics of radiological statistics that the radiologist does not do everything that the goiter surgeon does to make his statistics equally reliable. Formerly the attack on radiotherapy as a means of treating hyperthyroidism centered on the *absence* of statistics as to its value. Now

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

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<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept 25-30, 1933



that statistics are rapidly accumulating the attack has shifted to their comparable reliability and to the competency of the radiologist to deal with the disease

In a typical form hyperthyroidism presents but few difficulties in diagnosis, but particularly in view of the relative harmlessness of irradiating the thyroid many patients are being referred to the radiologist for therapy in which the problem of incriminating or absolving the thyroid presents many difficulties. Many such cases require prolonged clinical observation and repeated basal metabolic determinations. Without such critical study the statistics relating to hyperthyroidism will include many cases that do not properly belong there. Ten per cent of the cases coming to us with a diagnosis of hyperthyroidism fall in that group. The majority are made up of psycho-neurotics, constitutional inferiors, and the vascular hypertensives. When patients of these groups present themselves with a report of elevated metabolism, and particularly if there should be some thyroid enlargement, an expenditure of much effort is required to properly elucidate them, and in some the rôle of the thyroid may remain permanently doubtful. It is unfortunate that the fallibility of basal metabolic determinations is not sufficiently well recognized generally. If they do not harmonize with the clinical evidence any doubt as to the possibility of thyroid dysfunction should be resolved in favor of the clinical evidence until every one of the many possible sources of error in the metabolic determinations have been repeatedly checked and conclusively eliminated.

There has been very little variation in our method of treating hyperthyroidism during the past ten years.

At our first interview with a patient we tell him what we expect him to do and what we expect to accomplish. Such patients usually have many questions to ask and time should be taken to answer them frankly and in considerable detail. The principles of treatment and the results to be expected have become so thoroughly

established that there is no longer any justification for indefinite or evasive replies. In our earlier experience, many patients, after one or two treatments by irradiation, would abandon it in favor of surgery, but as confidence in the former has become more firmly grounded not only in our own minds but in the minds of our medical confrères and the laity such occurrences have become increasingly rare.

The general management of patients with hyperthyroidism is so well outlined in most of the standard text-books on the practice of medicine that it would seem unnecessary to stress it here but for the fact that the specialist is prone to underestimate its importance. Nothing that the radiotherapist or surgeon is able to accomplish in this disease obviates the necessity for physical rest, either complete or modified, as the degree of toxicity may indicate. For patients exhibiting marked toxicity, bed rest is insisted upon. They almost invariably rebel at the suggestion, but if the reasons for it are patiently and sympathetically explained, their wholehearted co-operation (which is considered highly important) can usually be obtained. More than six weeks of complete rest is seldom required even if a longer period is indicated, it is often desirable to permit sufficient liberty to maintain morale. For the milder cases, modified rest is prescribed. By a careful study of the occupational, social, and recreational habits of such patients their physical activities can usually be reduced at least 25 per cent without requiring undue sacrifices on their part. It is of considerable importance that the rest requirements of the individual patients be appraised as accurately as possible at the beginning of their treatment, as they are peculiarly susceptible to suggestions that seem adverse to their favorable progress, and it causes an unfavorable reaction if it becomes necessary to shift from partial to complete rest, especially if such a contingency has not been anticipated. Mental tranquility is no less important than physical rest. These patients need to be inspired with hope and confidence

in a successful issue, and this is always attempted, but never to the extent of overstepping the bounds of sincerity and perfect frankness. Mental conflicts should be corrected, fears allayed, and morale maintained.

Supervision as to food and water intake should not be neglected. Ordinarily medication is of minor importance. Sometimes sedatives are helpful, and, to meet special indications, such as cardiac decompensation, appropriate remedies are, of course, used. The use of iodine, with due regard to its limitations, is often helpful, whereas the surgeon uses it to prepare the patient for operation, the radiologist can at times use it advantageously until irradiation has time to become effective. Unfortunately, its use all too frequently leads to delay in instituting curative measures, and, by masking the symptoms of the disease, is apt to mislead the radiologist as to the amount of irradiation necessary to effect a permanent cure.

Foci of infection should be routinely sought for and eliminated as far as possible, due regard being given to the hazard that any operative procedure might entail. We have on a number of occasions seen rebellious cases proceed to prompt recovery after the removal of infected teeth or tonsils, and have reason to believe that some unsatisfactory results are traceable to irremediable focal infections.

Undoubtedly hyperthyroidism is successfully treated by irradiation with rather widely varying techniques. It is our practice to administer treatments at intervals of three weeks. Three areas are exposed, one over each side of the neck and one over the upper sternal region. The size of the portal is varied to conform to the anatomical structure, but we consider it important to irradiate the entire thyroid and thymic areas and the size of each portal is seldom less than  $8 \times 12$  centimeters. The marking off of the areas, the positioning of the patient, and the adjustment of the tube should be closely supervised by the radiologist and not left entirely to the discretion and judgment of a technician. The physi-

cal factors as to dosage are 5 milliamperes of current, 140 K V, 10-inch focal distance, and 5 mm aluminum filter—with these factors the administration of 200 r through each portal is regarded as entirely safe and is the dose routinely employed. We have never seen any immediate or remote deleterious effects on the skin or larynx when the roentgenologist adheres to it. No doubt favorable effects are manifested somewhat sooner and fewer treatments are required when larger doses are employed, and in selected cases we believe this method is justifiable, but, on the whole, the potential disadvantages of larger doses outweigh their advantages. Regardless of the ultimate result, we find that 38.5 per cent of this series of cases has been given six treatments or less, 39.7 per cent, more than six but less than ten, and 21.8 per cent, more than ten. The number of treatments which may be required in the individual case cannot be foretold, and any assurances given patients in that regard should be in terms of the average. Highly toxic cases may get well and remain well after three or four treatments, whereas mild cases may require three or four times as many. Indeed, it is our impression that the more the individual case deviates from the perfectly typical, full blown thyrotoxic syndrome, the more troublesome it is to treat. We have not set an arbitrary limit to the number of treatments to be given patients, but judge each on its individual merits. Improvement is usually manifested within two months from the beginning of treatment and is progressive.

We do not know of any contra-indications to the treatment of hyperthyroidism by irradiation. It is conceivable that in rare instances pressure symptoms may constitute an emergency, and, under certain conditions, particularly with respect to availability, treatment by irradiation may be less practical than surgery. Under such circumstances the latter is given preference. There are no logical reasons for combining the two methods except to the extent that where one has failed to cure, the other may be employed. Malignancy

has not supervened in any of the 557 cases treated by us, covering a period of 16 years, nor do we know of such occurrence in the practice of other radiologists. It is our belief that malignancy of the thyroid, particularly clinical malignancy, is a rare disease, and that the suggestion of operating on all adenomatous goiters with a view to preventing it is wholly misconceived. In a large series of cases at the Mayo Clinic (2) the ratio of malignant tumors of the thyroid gland to all simple goiters (colloid and adenomatous) was 1 to 36.7 (2.7 per cent). It is admitted that there are no data available as to the incidence of both conditions, and it is pointed out that most persons with carcinoma of the thyroid eventually seek medical advice for it, whereas many with nodular goiter do not. In 65 per cent of the cases of the Mayo Clinic series the diagnosis rested solely on the microscopic findings which, at least from a practical standpoint, are not necessarily final or conclusive. It is not altogether fanciful to assume that cells undistinguishable from malignant tumor cells might be uncovered in every human being past middle life, provided every cell in the body could be inspected under the microscope. It is highly probable that even now the aggregate number of deaths from surgical operations on the thyroid far exceed the number of deaths from cancer of the thyroid, and, if that be true, the recommendation of surgery as a preventive measure for the latter would appear to be founded on wholly fallacious reasoning. Other objections that have been raised to the irradiation therapy of toxic goiter are equally chimerical or inconsequential. The only pertinent considerations relate to its effectiveness and comparable safety in curing the disease.

Of the 252 cases comprising the present series, 55 (21.82 per cent) were classified as mild, 138 (54.76 per cent) as moderate, and 59 (23.42 per cent) as severe. Of the series, 202 (80.15 per cent) were cured, 39 (15.47 per cent) were improved, and 11 (4.38 per cent) were unimproved. Recurrence took place in 3 (1.19 per cent). Of

the series, 16 (6.35 per cent) had previously been operated on without cure. Of these, 12 (75 per cent) were cured, 3 (18.75 per cent) improved, and 1 (6.25 per cent) unimproved. Seven patients (2.38 per cent) were operated on after irradiation therapy had failed to effect a cure, the results in these cases being unknown. Five cases (2 per cent) developed hypothyroidism after irradiation; there were no other sequelæ. The average gain in weight for all patients of the series was 13.3 pounds.

Pursuing our usual policy with respect to follow-up of cases of hyperthyroidism, most of those in this series and many in our previous series are still kept under periodic observation. We find little difficulty in having such patients return for periodic check-up, provided they are given definite appointments, personal attention, and are not charged for the service.

Our own results are about on a par with those of other radiologists, particularly those who have treated a considerable number of cases. Menville (3) collected over ten thousand cases treated by radiologists scattered throughout the country, which show a remarkable uniformity in the results obtained.

There are now abundant data, equally comprehensive in detail and reliable as to pertinent facts, for comparing the results of irradiation therapy with those of surgery. Despite all that has been said as to their respective merits and demerits, the only vital consideration as to choice between them lies in the fact that the former is unattended by mortality, whereas the latter is attended by a definite mortality. This percentage of mortality, though low in the hands of the experienced goiter surgeon, is undoubtedly considerable in the hands of the average general surgeon. Both groups have probably about reached the limits of their efficiency and it must be admitted that both fall short of an ideal method of treatment for this disease.

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The first striking fact is that the voltage never drops to zero though this was a half wave valve machine with the only capacity that of the transformers. This is not quite so surprising, however, if we examine the current wave and note that for a goodly part of the cycle no current is flowing, which means that an extremely small capacity would be sufficient to maintain the voltage. It will be noticed that the voltage rises higher and falls lower on the hot tube. The current, on the other hand, has a much higher peak value for the cold tube.

Granting some cause for this high peak current for the moment, the explanation becomes simple. The load on the machine increases at this point of the cycle, which, due to the internal resistance of the transformers and controls, causes a lowering of the peak voltage. Now as the tube warms up the peak current falls off (the average current as read by the milliammeter being held constant), which relieves the load on the transformer at this point, with a consequent rise in peak voltage.

In an effort to find an explanation for

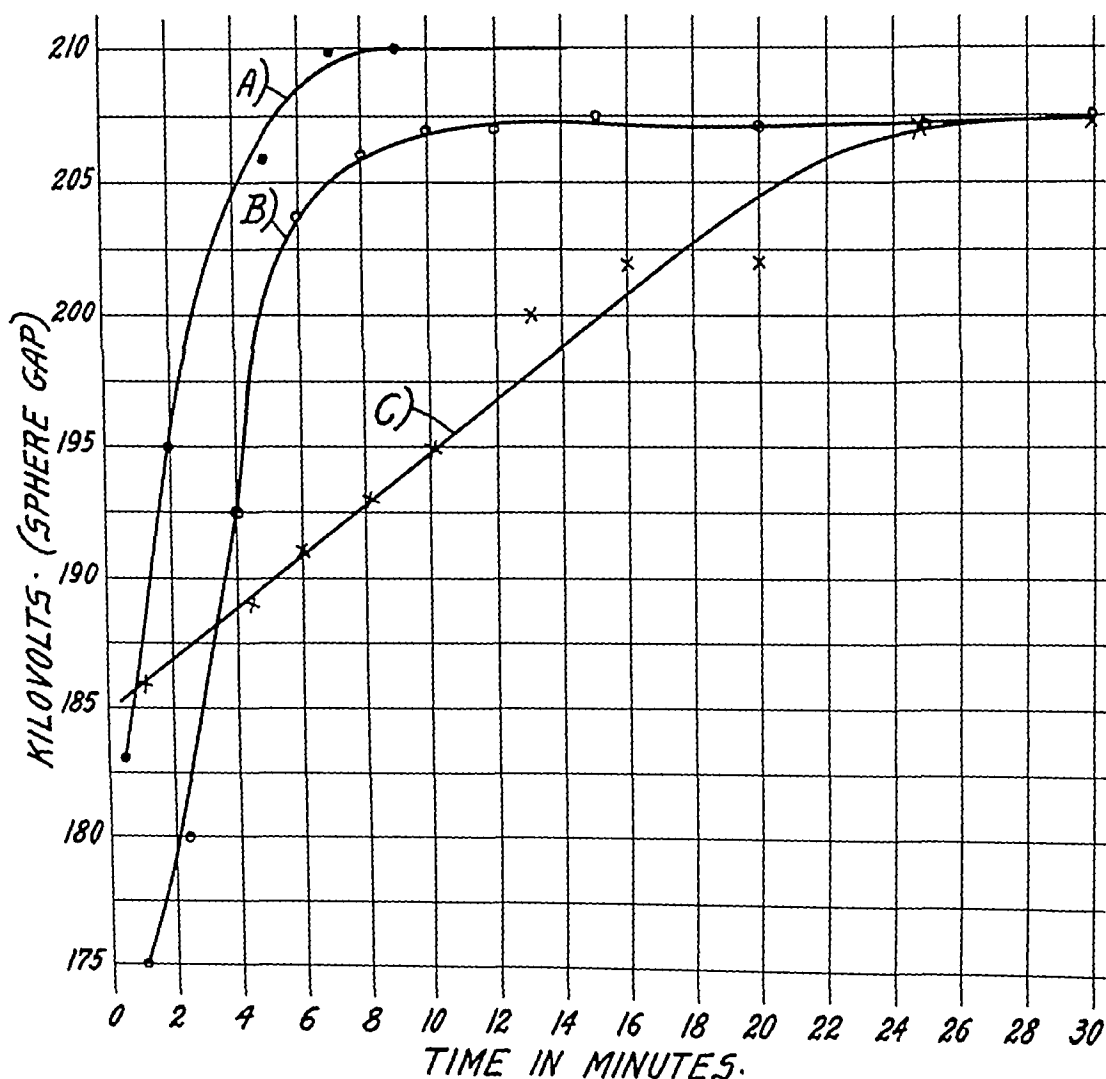


Fig 1 Curves showing voltage rise for (A), Pyrex therapy tube operated on full wave mechanically rectified machine at 8 Ma, (B), and (C), therapy tubes operated on half wave valve rectified machine at 4 Ma, (B), wall thickness  $\frac{2}{16}$  inch, (C), wall thickness  $\frac{1}{4}$  inch

# THE "RISE IN VOLTAGE" EFFECT OF THERAPY X-RAY TUBES<sup>1</sup>

By C M SLACK, PH D, and K O SMITH, PH D, Bloomfield, N J

Research Laboratory, Westinghouse Lamp Company

IN the past, one of the chief worries of the roentgenologist practising therapy has been the uncertain and usually short life of the deep therapy x-ray tube. These tubes were usually operated under the published ratings, yet a life of 200 hours was considered reasonably good. The tube usually failed by electrical puncture in some portion of the glass envelope. The introduction of heavy-walled pyrex bulbs and tubing in the manufacture of these tubes largely eliminated this difficulty and added greatly to the tube life and steadiness of operation.

It has been noted, however, by certain users of these new tubes that the voltage across the tube rises as the tube heats up, if the milliamperes are held constant. This voltage rise is usually accompanied by a corresponding, though smaller, change in the x-ray output.

The wide variations in this effect brought about by the different types of tubes and machines make our measurements to date too limited for anything but a qualitative report on the magnitude of this effect. The underlying cause, however, has been investigated more fully, and it is this phase of it which will be considered now in detail.

As a first step in this investigation, the variation in voltage and x-ray output, with time, was measured for a heavy-walled deep therapy tube operated on a full wave mechanically rectified unit. The current through the tube was held constant. The result is shown in Figure 1 (Curve A). The variation in output with this mechanically rectified unit was irregular but quite small, and was not plotted. The work was then continued on a half wave valve rectified machine,

with the rather striking results shown in Figure 1 (Curves B and C), and Figure 2. The equilibrium time for Curves B and C, Figure 1, is reduced to 5 and 12 minutes, respectively, at 6 milliamperes. As will be pointed out later, these curves cannot be taken as typical of these types of machines since the characteristics of the particular transformers and controls are the governing factors. The seriousness of this situation lies in the possibility of the users of these tubes either measuring the output or voltage before equilibrium conditions are reached. With certain machines, if the initial voltage is 200 K V, the equilibrium peak voltage could be as high as 250 K V, and the x-ray output increased 25 per cent. This would result in an overdose to the patient and an overload for the tube.

It was found necessary to wait between 15 and 30 minutes after turning off the power before the voltage would start at its lowest point. This gave us an opportunity to determine whether the time effect was in the tube or transformer. By connecting two tubes in parallel across the high voltage terminals with independent filament controls, first operating one tube and then the other, it was possible to determine that the time element depended on the tube alone. Yet the effect was not independent of the generator, since the same tube showed a different rise on a different generator. It was suspected that there must be some change in the tube characteristics on heating, which, in turn, influenced the wave form of the high voltage generator.

This wave form change was investigated by means of a cathode-ray oscillograph with connections as shown in Figure 3. Figure 4 shows the type of current and voltage waves obtained by this method for cold and hot tubes.

<sup>1</sup> Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov 28-Dec. 1, 1932

termines the peak milliamperage and when this is lowered there is a corresponding drop in the load on the transformer, resulting in a peak voltage rise. It is interesting to note, in Figure 4, that, with

portion of the voltage wave second, when the tube warms up the maximum voltage increases but a smaller percentage of the current is flowing at this time.

Thus the change in quantity and quality

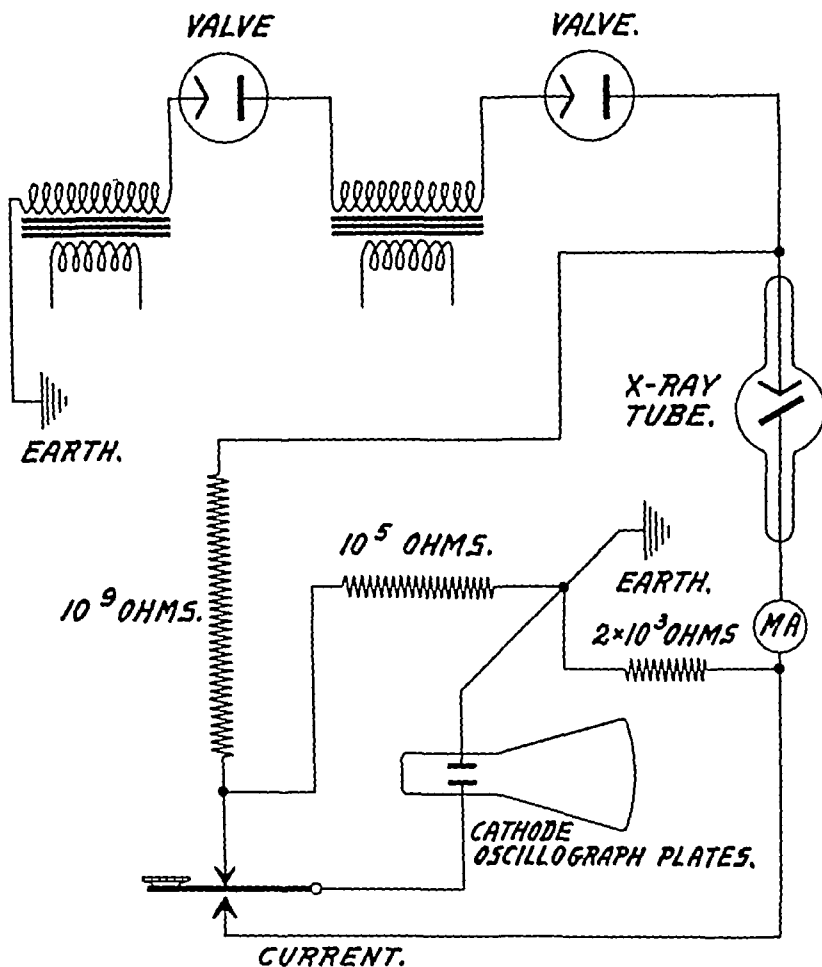


Fig 3 Wiring diagram of generator and oscillograph for obtaining voltage and current waves

a heavy-walled therapy tube operating at 200 K V and 10 ma, the tube is passing at the peak of the voltage wave 44.5 ma, when cold, and 26.6 ma, when hot.

The effect of these wave form changes on the x-ray output is not so large as one might expect since there are two factors involved which tend to neutralize one another. First, with a cold tube the peak voltage is low but a large part of the current flows through the tube at this

of the x-ray output is intimately tied up with the generating equipment. On some machines the output will go up, and on others down, as the tube heats up. Fortunately, in most cases the change in output is not so great as would be expected by the change in voltage.

An interesting exception to this rule is an ideally built pulsating machine in which there is no appreciable energy loss in the controls or transformer. Thus



this change in peak current value a special tube was used. Three equally spaced conducting rings were painted on the inside of the bulb, having their centers on the tube axis. These were connected through the glass to corresponding rings

velocities close to that of the primary beam.

Now referring to the curves showing the voltage and current waves (Fig 4), the explanation of the whole phenomenon becomes as follows:

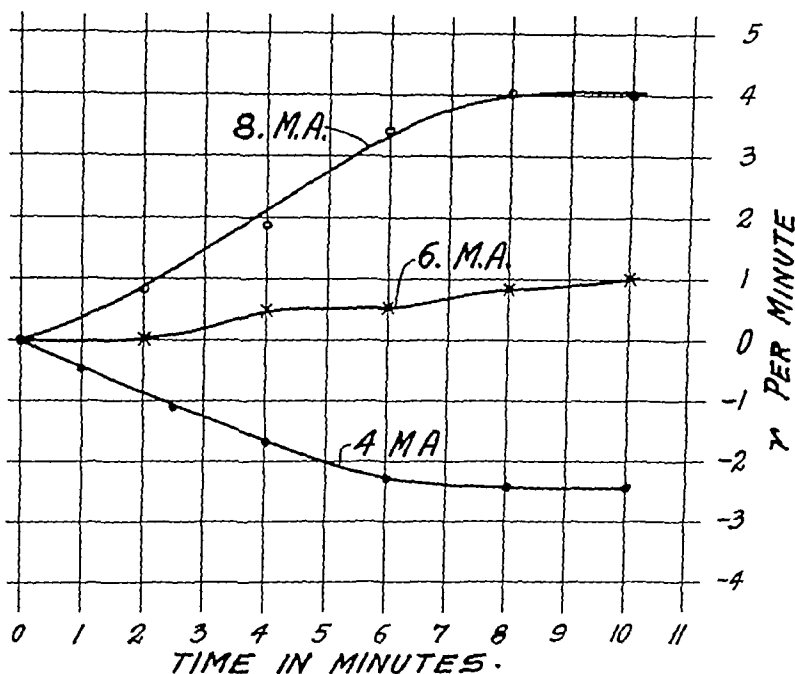


Fig 2 Curves showing change in therapy tube output with time for three current values. Half wave valve rectified.

on the outside. Between the central inner ring and the lead-in wire there was a gap of about an inch where the conducting material had been removed. When this tube is operated cold, even as low as 100 K V, there is violent sparking over this gap, showing a large potential difference between the inner and outer surfaces of the bulb. When the bulb becomes hot this sparking stops and the tube operates normally—the glass of the bulb has become conducting. When these seal-in wires are connected through a milliammeter to ground, as much as 15 milliamperes will flow with a tube current of 8 milliamperes. This current flow is in the proper direction for electron flow to ground, and is due to scattered electrons from the target, some of which have

When the pyrex glass is cold it is a good insulator, thus the scattered electrons from the anode charge the inner surface of the bulb to a potential equal to that of the cathode at the peak of the voltage wave. As the tube voltage falls during the next part of the sine wave, this negative charge remains and acts like a grid, preventing electrons from leaving the filament. When the tube is hot the glass becomes conducting, thus allowing the charge to dissipate through the bulb walls, which, in turn, permits more current to flow from the filament at the lower voltage portions of the sine wave. The filament temperature must then be lowered to maintain the 8 ma average current as shown by the milliammeter.

The filament temperature, however, de-

termines the peak milliamperage and when this is lowered there is a corresponding drop in the load on the transformer, resulting in a peak voltage rise. It is interesting to note, in Figure 4, that, with

portion of the voltage wave second, when the tube warms up the maximum voltage increases but a smaller percentage of the current is flowing at this time.

Thus the change in quantity and quality

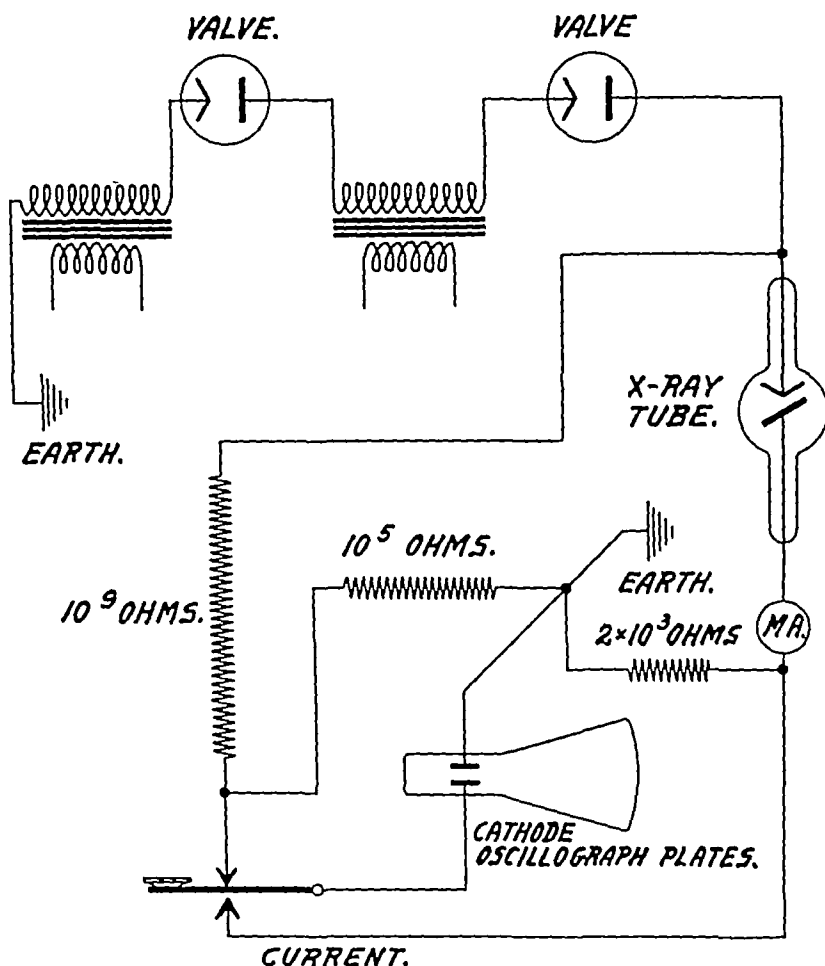


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An interesting exception to this rule is an ideally built pulsating machine in which there is no appreciable energy loss in the controls or transformer. This

machine shows no voltage change but a lowering of some 25 per cent in x-ray output, with the establishment of equilibrium conditions at 200 K V and 8 ma. The oscillograph also explains this as being due to a broadening of the current wave, with a corresponding fall in the current flowing at the crest of the voltage wave.

In practice there are three ways of overcoming these variations in voltage and tube output

- I By the use of a constant potential machine,
- II By the operation of the tube in a manner to keep the glass cool,
- III By allowing sufficient time for the tube to reach temperature equilibrium

I The constant potential machine, except for the expense involved, offers an ideal solution for the problem. The output and voltage are the same for hot and cold tubes. There are no wave form troubles with which to bother. It gives a real meaning to voltages as measured by a sphere gap or electrostatic voltmeter.

It is by far the most efficient type of x-ray generator, and, in spite of some opinion to the contrary, is probably the easiest on the tube.

II If the pyrex glass is maintained at a temperature below  $100^{\circ}\text{C}$ , it retains its insulating properties and the output and voltage will remain constant.

TABLE I—SHOWING THE APPROXIMATE OUTPUT IN "r PER MINUTE" FOR THREE COMMONLY USED TYPES OF MACHINES 200 K V, 8 MA, 50 CM DISTANCE, 0.5 MM CU PLUS 2 MM AL FILTER

Constant potential	Full wave mechanically rectified	Half wave valve rectified
34.0	22.5	17.0

III In practice, at the present time, a large majority of the outfits in use are half or full wave rectified either valve or mechanical. With these, the simplest solution is to measure the time required for the establishment of equilibrium conditions under which the work is being conducted and to wait this interval before measuring.

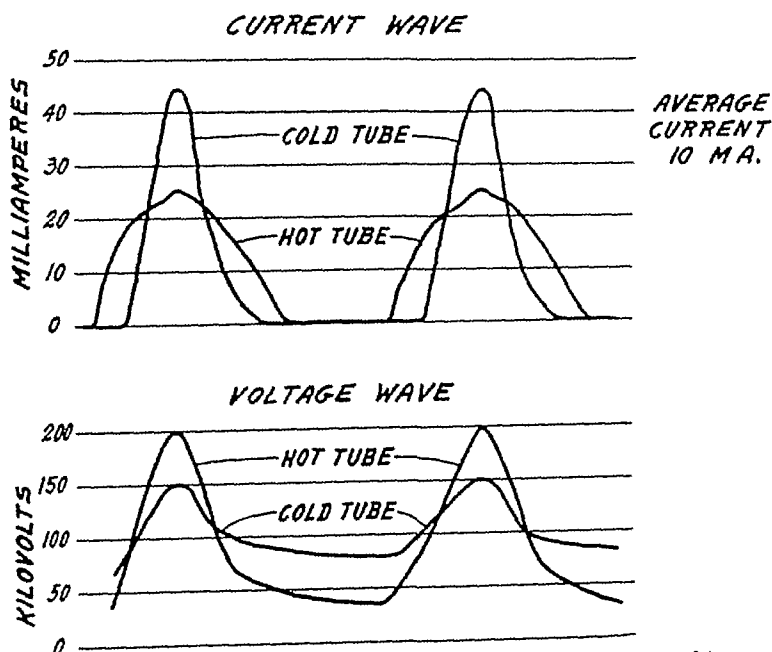


Fig 4 Oscillograph picture of current and voltage characteristics of heavy wall deep therapy tube on 60 ~ half wave valve rectified machine.

either voltage or output. At 8 ma, the longest equilibrium time was about six minutes, whereas at 4 ma it varied between eight and twenty minutes, depending largely on the tube wall thickness.

Since the preparation of this manuscript our attention has been called to an abstract which appeared in the program of the American Roentgen Ray Society at their meeting, Sept 27 to 30, 1932, at Detroit, Michigan, entitled "The Behavior of Different Types of Deep Therapy X-ray Tubes on Different Types of Generators," by Lauriston S. Taylor, Washington, D. C. This abstract considers certain phases of the problem dealt with here.

#### DISCUSSION

DR A. MUTSCHELLER (New York City) Dr. Slack's paper touches on a subject upon which I have been making observations for a long time. In calibrating many different types and makes of deep therapy apparatus, I have frequently found that there are changes in the radiation intensity during the first few minutes of operation of the tube and the machine. While keeping in mind all the data that might have a bearing on this subject, I came to the conclusion that there are three factors involved as being responsible for the changing output—one being the tube, and the other two being connected with the high voltage generating equipment.

In my laboratory, I had an opportunity fully to investigate the characteristics of tubes with constant potential current, and I found that some tubes do have definite characteristics, or do undergo definite changes during operation as time goes on. These are, of course, typical tube changes, namely, a gradual decrease of milliamperage due to adjustments between the heated parts of the tube, and the remaining gas pressure. However, with careful and pro-

longed operation, these conditions usually clear up in a manner which is generally well known as seasoning of x-ray tubes. Therefore, these changes are distinct and they are easily recognized as against the changes that are dependent upon the machine.

With some types of machines, especially those in which the transformer iron is very highly saturated, I found that, ordinarily, it takes from seven to ten minutes for the radiation output to become constant. Before that time, the output is lower (I should say, on an average, about 20 per cent) than the final equilibrium radiation intensity, and it increases gradually. Very often the voltage, as indicated by the sphere gap measurement, also increases. These, of course, are observations while the heating current or the milliamperage of the tube are kept constant and while the control remains unchanged.

Another type of apparatus which I tested, and which produced constant potential without any superposed high frequency or unduly large ripples, brings the tube to equilibrium in a very short time and, ordinarily, there are no changes except possibly such as are due to heating of resistances when they are present. Therefore, for the proper operation of x-ray tubes with constant potential, there should be used a minimum of ballast resistance so that the condensers are always fully charged to normal voltage. If a large amount of ballast resistance is used, then we have changes, caused by heating of resistances, or of the type reported with one of the previously mentioned types of machines.

I reached the conclusion that radiation changes during the first minutes of tube operation are due, first, to seasoning of the tube, second, to magnetically oversaturated iron cores which take about eight minutes to come to an equilibrium, and third, through heating of regulating resistances, if such are present.

# HIP JOINT CHANGES IN HEMOPHILIA<sup>1</sup>

By MAX KAHN, M D , *Baltimore, Maryland*

WHILE there are many cases of hemophilia in which joint disturbance is one of the outstanding symptoms of the disease, there are other cases in which the patient may remain free from joint symptoms throughout his lifetime. Schloessman (1) estimates that one-third of all hemophiliacs are free from joint symptoms, whether sporadic cases be examined or whether the members of a single family of males be investigated.

The usual onset of symptoms is in the first or second year, following the small injuries to which the joints are normally subjected. Many cases, however, appear to have their onset between the ages of 9 and 13 years, just before adolescence. Apparently hemorrhages in the region of the joints, which are responsible for the hemophilic arthropathy, may, in some cases, occur spontaneously. The knee joint is by far the most frequently involved, followed in the order of their frequency by the elbow, ankle, and hip joints. The hands and shoulder joints are rarely involved. In isolated instances, the fingers or the temporomandibular joints may be affected.

In the German literature, joint changes in some cases have been followed for fourteen or fifteen years. In one case, at the age of two, the pain and heat appeared spontaneously, producing a swelling in the sternoclavicular and ankle joints. From that time on to the age of 10, there was pain and limitation of motion in the various joints of the arms and legs, usually lasting for from six to eight days. As a result of these, the knee, elbow, ankle, and hip joints became affected. Most of the attacks occurred without noticeable trauma. In one instance, there was a large hemorrhage into the left knee joint, resulting in flexion and limitation of motion

which confined the patient to bed. At the age of 15, the patient had marked enlargement of the left elbow and marked contraction of both knees, which were flexed to about an angle of 45° on the left, and 90° on the right. Both knee joints were thickened and painful. With the exception of the elbow, the other joints remained free from permanent changes. At the age of 30, there were permanent contractures about the left knee so that the patient was compelled to walk on crutches.

In the first or second year of the joint disturbance, the roentgenogram is usually negative. Later, when limitation of motion occurs in the joint, the roentgenogram will show atrophy of the neighboring bones. This is followed by destruction of the joint surfaces, with peri-articular irregularities, resembling arthritis deformans. The joint cartilage disappears and the joint surfaces approach each other. Synostosis may occur. Accompanying these intra-articular changes, there are usually peri-articular manifestations. The earliest of these may be a hazy shadow in the soft parts, caused by peri-articular hemorrhage, which later may be followed by calcification and ossification. The bones about the joints become enlarged and broadened across their articular surfaces.

In the early stages, the roentgenologic changes may resemble those of tuberculosis, osteochondritis, or coxæ juvenilis, later they simulate osteitis deformans. The family history and the patient's past history of bleeding are the most important factors in the differential diagnosis. Another point of differentiation is the short duration of the pain, which subsides after from four to six days in the hemophilic joint. In the other conditions mentioned, the pain is more chronic, tending to become constant. It is only when there are marked peri-articular shadows, with signs of ossification about the joint, that the roentgenogram may be characteristic.

<sup>1</sup>Read before the Radiological Society of North America, at the Eighteenth Annual Meeting at Atlantic City, Nov. 23-Dec. 1, 1932.

Key (2) is of the opinion that bony ankylosis in hemophilic arthritis does not occur. He states that the changes in the cartilage which are characteristic of a hemophilic joint have a map-like appearance, due to cartilage destruction, and that the characteristic change in the bone is the formation of cavities in the intra-articular portion. He believes that bone destruction does not occur until late in the disease, and that at some stage of the disease, the bone becomes markedly atrophic as a result of disuse. The areas of bone destruction are frequently so extensive that they are clearly visible in the roentgenogram.

Marked hemarthrosis, due to bleeding within or about the joints from the synovial membrane or peri-articular structures, is most common in the region of the knee or elbow. Roentgenographically, changes about the hip joints of hemophiliacs, however, are rare. Lohr (3) reported two patients of pre-adolescent age who showed typical signs of osteochondritis deformans juvenilis. Reviewing the literature in regard to these changes in the region of the hip joint, he found that the bleeding might be intra- or extra-articular, and that bleeding before puberty usually gave rise to osteochondritis, whereas, at a later age, coxa valga or cyst-like formation in the neck of the femur might develop.

Recently a case of hemophilia (4) was treated by intramuscular injection with ovarian extract, with excellent result. Birch (5) is credited with the discovery that a hormonal disturbance exists in hemophilia which is temporarily relieved by parenteral administration of ovarian substances. The potential value to surgery of the clinical application of Birch's discovery is obvious.

I will report briefly two cases, one a white male, aged 19, with extra-articular changes about the hip joint, due to hemophilia. This will be contrasted with a similar case in a younger patient in whom the changes were intra-articular, emphasizing the point that the age has a definite bearing on the pathology produced.

## CASE REPORTS

Case 1 White, male, aged 19 years. The patient complained of pain in the right hip joint, present for about two weeks before this examination, and pain in the left hip joint which had been present for



Fig 1 Case 1. Large bony shadow in region of left hip joint of hemophiliac, probably present for a long while. Examination, made for recent pain in right hip joint, was negative.

about two years, not preceded by a history of trauma. There was no relative history obtainable in regard to the present illness. The patient has two sisters living and well, who are not hemophiliacs. He has four brothers living who are known to be hemophiliacs, as is the patient. One brother, aged 7 years, died from intracranial hemorrhage 10 days after an injury to the head. Horse serum was used, and also his father's blood intramuscularly, but without benefit. As a young man, the father suffered from frequent nose bleeding, but there had been no hemorrhage in adult life. There was no history of hemophilia on the paternal side. The mother is not a hemophiliac, and there are no hemophiliacs on the maternal side.

*X-ray Examination*—On Aug 16, 1932, examination of the pelvis and hip joints revealed no change in the right hip joint, the site of the recent pain. However, there was a definite large bony shadow

near the left hip joint, which may be associated only with this hemophilic history

Case 2 White, male, aged 12 years The patient was a hemophiliac, with ankylosis of the hip The knees and elbows showed slight changes, apparently chiefly developmental A first cousin and an uncle were hemophiliacs

*X-ray Examination*—Roentgenograms made on Aug 30, 1932, showed a juvenile pelvis There was bone absorption around the acetabular cavity on both sides, with ankylosis on one side and shortening

From the history, the diagnosis was hemophilia of the joints

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# REPORT OF COMMITTEE ON STANDARDIZATION OF X-RAY MEASUREMENTS

SUBMITTED FOR THE COMMITTEE BY LAURISTON S TAYLOR, CHAIRMAN<sup>1</sup>

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### I RECOMMENDATIONS TO BE SUBMITTED TO THE INTERNATIONAL X-RAY UNITS COMMITTEE

1 The International Unit of X-radiation shall be called the "roentgen" and shall be designated by the symbol  $r$  (lower case letter)

2 The roentgen is the quantity of  $\gamma$ -radiation which, when the secondary electrons are fully utilized and the effects of scattered radiations avoided, produces in 1 cc of atmospheric air at 0° C and 76 cm mercury pressure, such a degree of conductivity that one electrostatic unit of charge is measured under saturation conditions

3 Irradiation expresses the quantity per unit time, it shall be given in roentgens per minute ( $r/m$ ) as measured in air

4 All data given in roentgens shall apply to the incident radiation, excluding scattered radiation

5 Inasmuch as the determination or calculation of tissue dose, representing the amount of radiation received by the skin or any part of the irradiated tissue is uncertain, all data relating to tissue dose (sum of incident radiation and scattered radiation in the tissue) shall be designated as "tissue dose" if expressed in roentgens

6 Since satisfactory agreement regarding methods for measuring the roentgen has been established between the several

National Standardizing Laboratories, various standard methods may be employed to establish the unit

7 Secondary ionization chambers shall be calibrated against the standard chamber for the range and purpose for which they will be used. It is desirable that the relation of such chambers to the standard chambers vary as little as possible with wave length

8 The practical instruments employed for the measurement of  $\gamma$ -rays shall be designated as follows

(a) "Irradiometer," an ionization instrument which gives a continuous indication of the irradiation

(b) "Roentgenometer," an ionization instrument which measures the quantity of x-radiation (time integral of irradiation) in a given deflection of the indicator

9 The constancy of the calibration of an irradiometer or roentgenometer shall be tested by the ionization produced in the measuring chamber by means of gamma radiation under fixed conditions from a definite quantity of radium element. Such measurements shall be suitably corrected for the atmospheric temperature and pressure under which the tests are carried out

10 Specification of the quantity of x-radiation shall always be accompanied by a specification of the quality of the x-radiation. Quality is the wave length energy distribution in the x-ray spectrum. For most practical purposes the quality of the x-radiation may be satisfactorily specified in terms of the copper or aluminum absorption curve combined with a statement of the initial filtration. In lieu of an absorption curve, the equivalent constant potential applied to the tube terminals to yield the same curve may be stated as a single numerical magnitude. Up to 100 K V (constant) aluminum ab-

<sup>1</sup> The preparation of this report was begun under the chairmanship of E C Ernst, M D



sorption curves and above 100 K V (constant) copper absorption curves shall be used to establish the equivalent potential

11 The report of a roentgen treatment shall include, in addition to the total number of roentgens and the quality, the following factors

- (a) Durations of, and intervals between, irradiations,
- (b) Distance from target to skin,
- (c) Size of field

## II DISCUSSION OF THE RECOMMENDATIONS

¶ 1<sup>2</sup> Regarding the name and symbol for the International Unit of X-radiation, emphasis should be directed to its use in relation to units in other fields. The name should always be spelled with a small r, and the symbol always a small (lower case) r. Use of the term "r-unit" or "roentgen-unit" should be deprecated since such expressions are entirely out of keeping with accepted physical nomenclature. (See note in RADIOLOGY, 1930, XV, 305)

¶ 2 Some serious objections had arisen regarding the wording of the definition of the roentgen and the definition itself. The question before the Committee was how far to go in recommending changes in an internationally accepted definition, and it was decided to change the definition as little as possible but still bring it into an unambiguous and more usable form. At the same time, the Committee wishes to put itself on record as preferring a definition which has a better physical foundation.

In March, 1928, this Committee recommended a definition for the unit of "Effective X-ray Intensity." It is still felt that such a definition would be superior to the present one, in that it defines an x-ray beam in terms of intensity rather than quantity. By defining the roentgen as an intensity, much of the confusion in expressing dosage would be avoided. Since the quantity definition is now so widely

used, the Committee does not urge this change unduly.

The present international definition has, however, a potentially embarrassing omission. It is only by fortunate circumstance that this omission has not already caused difficulty, in that below 150 K V (r m s) its effect is almost negligible. The present definition does not mention scattered radiation, and it may thus be assumed that in measurements of the roentgen, the effect of scattered radiation may be neglected. However, one of the most important uses of the roentgen, particularly at higher voltages, is to permit a proper evaluation of x-ray dosage in comparison with that at ordinary voltages. It is necessary, therefore, that over the whole voltage range the roentgen be the measure of a quantity which can be translated into actual energy absorbed by tissue. Since the roentgen is proportional to the energy absorbed from the beam by air, it is necessary, therefore, to restrict conditions so that the absorption will be known. At tube voltages below 150 K V (r m s) the absorption is largely photo-electric, whereas at the higher voltages, absorption is due principally to the energy removed from the beam by the recoil electrons in the Compton scattering process. (This is discussed in detail by C. C. Lauritsen, *Am Jour Roentgenol and Rad Ther*, 1933, XXX, 380-387 and 529-532.)

The question then arises as to whether the definition should or should not include the effect of scattered radiation. If it should, we are confronted with the problem of how to devise an apparatus which will definitely include all of it. Technical difficulties at the higher voltages—above 150 K V (r m s)—seem at present to render this impossible. Should we then include only a definite fraction of the scattered radiation in the measurement and, if so, what shall that fraction be and how shall we define and determine it? As this does not appear feasible with our present knowledge the only alternative in making measurements is to avoid all effective secondary radiation as far as possible, and

\* Paragraph numbers refer to the new recommendations given in Section I

to reword the definition so as to embody the necessary conditions

Our recommended definition appears to be capable of realization at high voltages without going to excessively large ionization chambers. Photographs made in a Wilson cloud expansion chamber 30 cm in diameter (Lauritsen) show that for a narrow 700 K V  $\gamma$ -ray beam practically all of the ion paths are confined within 10 cm of the beam, and the bulk of them within the geometrical beam. Furthermore, it is seen that practically no ion tracks *originate* in the space outside the geometrical beam. This shows clearly that (1) the effect of radiation scattered from the chamber walls is negligible, and (2) there is no appreciable ionization due to photo or recoil electrons produced by secondary (degraded) radiation scattered out of the main beam. (The presence of tracks originating outside the beam indicates the entrance of a scattered quantum into that region, with the subsequent collision with an air atom and the production of measurable ions.)

The objection might be raised that, whereas the definition of the roentgen definitely excludes scattered radiation, it is impossible to realize this condition experimentally. It must be pointed out, however, that it appears to be possible experimentally to include not more than 1 per cent of the measured ionization as due to scattered radiation. Furthermore, it is possible to make rough corrections for the effect of the remainder of the scattered radiation and thereby reduce its net effect to less than 1 per cent of the total. Thus, although we cannot quite realize the ideal definition, its value is in no way impaired.

The newly defined definition can be realized by the use of (1) suitable diaphragms to stop secondary x-rays and secondary electrons from the filters and diaphragm edges from reaching the measuring volume, (2) a narrow and well-defined  $\gamma$ -ray beam, and (3) materials of low atomic number for the walls and electrodes of the chamber. If the diameter of the beam is sufficiently small in comparison with the

distance in which the beam loses, say, half its energy, then the fraction of the degraded radiation which is absorbed in the measuring volume directly, or scattered back from the surroundings, may be neglected. Since the energy absorbed from the beam is transferred largely to recoil electrons and thence to ions, it may be determined directly from the measured ion current which gives the number of ion pairs. It is obvious that the inclusion of an appreciable amount of scattered radiation would render such a determination very uncertain at best.

It will be noted that in the proposed new definition of the roentgen we have deleted the phrase "and the wall effect of the chamber avoided." This is done for simplicity since "wall effect" merely refers to secondary radiation, and by the new definition "scattered radiations avoided" covers this also.

Confusion in the present international definition is also brought about by the consecutive inclusion of the terms "conductivity," "esu of charge," and "saturation current," which frequently leads to a misinterpretation of the definition by physicists and engineers who are not thoroughly conversant with the field, hence, the change from "at saturation current" to "under saturation conditions."

The considerations outlined above led the Committee to consider ideal physical definitions of the roentgen which would avoid any possible ambiguity, such as exists with the present definition. One such definition might be of the following form:

"The roentgen is the time integral of that flux density of radiation which, when the secondary electrons are fully utilized and the effects of all scattered radiation avoided, produces in one gram of air one electrostatic unit of charge in ion pairs." The quantity of radiation corresponding to the unit under this particular definition would be about  $1/800$  that of the present roentgen. To make the unit, under this definition, of the same size as the present roentgen would necessitate a change in the definition from 1 esu to 773.4 esu or a

change from 1 gram of air to 0.001293 gram. Another possible improvement in the definition might be obtained by substituting for the last phrase in the definition above, "produces in 1 gram of air,  $1,621 \times 10^9$  ion pairs." This last would be in agreement with the present international definition.

It should also be pointed out in connection with our proposed definition that the term "secondary radiation" may itself need further definition. This is particularly so at x-ray potentials in excess of  $1.2 \times 10^6$  volts where it may be necessary to consider the effect of neutrons, protons, recoil nuclei, etc. Thus a rewording of the definition along the following lines may be indicated: "The roentgen is the quantity of x-radiation which, when all electrons and positive ions produced by secondary processes and processes of higher degree are measured, and the effects of all scattered radiations involving interaction of material outside of the measuring volume are avoided, produces in one gram of air one electrostatic unit of charge in ion pairs." It is obvious that with the increasing use of ultra-high voltages the present definition of the roentgen should be subjected to a very close scrutiny.

¶ 3 The term "irradiation" is substituted for "intensity" to avoid confusion caused by analogies between x-ray definitions and light definitions. With the roentgen defined as above for the *quantity* of x-radiation, the term "intensity" should not be used to describe the number of roentgens per unit time. To preserve the analogy to the universally accepted light definitions, use of the term "intensity" would require a different definition of the roentgen. The term "irradiation" has been used sufficiently in the sense of the above definition to warrant its general acceptance. The use of this term to express the roentgens per unit time offsets the disadvantage involved by defining the roentgen as a "quantity" of radiation.

To avoid troublesome fractions, irradiation is given in roentgens per minute (r/min) rather than in roentgens per

second, inasmuch as irradiations used clinically are usually greater than 1 if expressed in r/min.

¶ 4 This paragraph has been reworded to avoid the self-contradiction of ¶ 5 of the 1931 International Recommendations (see Section III). Since the roentgen is defined in terms of the ionization in free air, measurements made with a thimble chamber on the skin or at a depth (both producing scattering) are not in terms of true roentgens because of the wall effect. For measurements made on the skin or at a depth, the results must be described in some unit other than the roentgen. This emphasizes the need for a unit of tissue dosage, and such a unit is now under consideration by the Committee.

¶ 5 This is to amplify ¶ 4 above and show how to designate such measurements as are made where tissue scattering is included.

¶ 6 This replaces ¶ 4 of the 1931 International Recommendations, which was more or less without significance. It serves to emphasize the fact that there is generally satisfactory agreement between the x-ray standards of several countries. It should not, however, be obligatory to use different standardization methods.

¶ 7 This is principally a rewording of ¶ 6 of the 1931 International Recommendations to emphasize the need for calibrating secondary ionization chambers for the *exact* purpose for which they will be used.

¶ 8 The term "dosage meter" for the practical clinical measuring instrument has led to a great deal of loose thinking and misconception regarding the significance of roentgen measurements in the radiologic clinic. A dose is a product of the number of roentgens by some factor which takes all scattering into consideration, hence, it is obviously impractical with our present knowledge to devise a simple physical instrument to measure such a quantity. The secondary instruments ordinarily employed measure only in terms of roentgens and, as shown above, are only strictly valid when measuring the beam without

scattering Measuring instruments fall into two distinct classes—one which measures the irradiation of a beam and the other which measures the quantity of radiation in a given time To avoid confusion and avoid use of the term “dosage meter,” it is desirable to distinguish between these two classes of instruments

¶ 9 Control of the constancy of a secondary measuring instrument according to the 1931 International Recommendations is not necessarily positive unless the ionization is produced in the chamber itself by the gamma rays (For example, a gamma ray test applied to the electroscope or an auxiliary chamber would not necessarily detect a broken collector electrode in a thimble chamber) Control measurements made in accordance with the above will invariably detect faults in the instrument There is no doubt but that irradiatorimeters and roentgenometers will eventually be in the same class as voltmeters and ammeters, and that the methods for testing their constancy will be abandoned If such instruments are reliably and ruggedly constructed, then methods for testing their constancy should not be required outside of the calibration of the instrument with a standard air chamber

¶ 10 (Replacing ¶ 9 of the 1931 International Recommendations) In the past, radiation qualities have been expressed in a variety of ways, most of which have their favorable aspects These included half value layers in copper or aluminum, effective wave length (5 varieties), average wave length, and full absorption curve The half value layer method has been most generally used (at least abroad) but, as in the case of the full absorption curve, requires a number of separate measurements for its determination The full absorption curve method has been repeatedly shown theoretically and experimentally to give an adequate representation of the composite radiation quality, and from such a curve all other expressions of quality may be directly derived Thus the future use of such a curve for expressing quality

will permit immediate correlation with all quality data presented in the past by whatever method This is not readily possible with any other methods now in vogue

A difficulty in the past in the use of a full absorption curve for describing quality was the inability to express it as a single numerical magnitude However, this may now be avoided by referring as a base to the absorption curves obtained with constant potential Thus an absorption curve starting with a stated filter may be expressed by the constant voltage necessary to produce it, and hence all qualities of radiations may be reduced to terms of an equivalent constant potential Such a method is of distinct advantage in comparing x-ray beams produced by generators of widely different wave forms This is also important at voltages up to 1,000 K V, such as are now being used in this country clinically The voltage wave form of such generators vary from a constant one to one with very narrow peaks, and at a given peak voltage the quality and effectiveness may vary between wide limits By comparing the absorption curves of such radiations with the absorption curve for a constant potential, they may all be reduced to a common base and the voltages may all be expressed as some equivalent voltage

¶ 11 (Replacing last sentence of ¶ 9 of the 1931 International Recommendations) The requirement has been added that, in reporting a roentgen treatment, the skin-to-target distance be given The need for this is obvious because of the influence of the skin-to-target distance upon the percentage depth dose

### III 1931 RECOMMENDATIONS BY THE INTERNATIONAL COMMITTEE

(1) The International Unit of X-radiation shall be the quantity which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 c.c. of atmospheric air at 0° C, and 76 cm. mercury pressure, such a degree of conductivity that one electro-

static unit of charge is measured at saturation current

(2) The International Unit of X-radiation shall be called the "roentgen" and shall be designated by the letter "r"

(3) The "intensity" of the radiation shall be expressed in r per second

(4) Various standard methods shall be employed to establish the unit

(5) All data given in roentgens (r-units) shall be supplied with an index to distinguish between the incident dose which does not include the scattered radiation, and the effective dose which includes the scattered radiation

(6) For all comparative purposes it is advisable to employ ionization chambers which have been calibrated in terms of a standard chamber for x-radiation of the various qualities employed. It is also advisable to make the wall effects of these chambers as small as possible

(7) The practical instrument used to measure x-ray output shall be called a dosage meter (dosismesser, dosimetre)

(8) The constancy of the indications of the dosage-meter shall be tested by means of gamma radiation emitted from a definite quantity of radium element, the measurement being carried out always under the same conditions

(9) Any specification of dosage is incomplete without specifying the quality as well as the quantity of the radiation. For practical purposes it suffices to specify the quality of the x-radiation in terms of the half value layer in copper when this value exceeds 0.1 mm of copper, or in terms of the half value layer in aluminum for radiation of less penetration, in all cases the value of the maximum voltage applied to the terminals of the tubes shall

be stated. The specification of the dosage shall also include in addition to intensity and quality such factors as the intervals between the times of irradiation and size of field

The International X-ray Unit Committee further recommends that

(1) The experimental methods of establishing a standard for the determination of the International X-ray Unit shall be entrusted to a sub-committee consisting of the following members of the Unit Committee: M. de Broglie (France), W. Friedrich (Germany), E. A. Owen (Great Britain), R. Sievert (Sweden), I. Solomon (France), E. Pugno Vanoni (Italy), L. S. Taylor (U.S.A.), (Honorary Secretary of the Committee, E. A. Owen). This Committee shall invite the collaboration of the various existing national bureaus for standard measurements and also those about to be instituted

(2) This Committee shall consider (a) methods of controlling the constancy of dosage meters, (b) the correlation of x-ray and gamma-ray dosage, (c) the establishment of a gamma-ray unit of intensity

(3) The progress of the work done by the sub-committee shall be reported once a year to the members of the International X-ray Unit Committee

(4) Each country shall be requested immediately to elect its two representatives on the International X-ray Unit Committee, until new representatives are elected the present members shall serve

(5) The International Committee shall henceforth be called "The International Committee for Radiological Units"

Approved by the Committee in Chicago,  
Sept 27, 1933

# THE SIGNIFICANCE OF OSSEOUS CHANGES IN THE ROENTGENOGRAPHIC DIAGNOSIS OF TUMORS OF THE SPINAL CORD AND ASSOCIATED SOFT TISSUES<sup>1</sup>

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DESPITE continued refinements in neurologic diagnosis which have contributed to earlier recognition of the presence of tumor of the spinal cord, roentgenology, except for the employment of lipiodol advocated by Sicard and Forestier (13), in 1922, contributed little until recent years toward the diagnosis and localization of these tumors. Even after the advent of Sicard and Forestier's method, which directed the attention of roentgenologists to these lesions, few attempts were made to search for other roentgenologic criteria, despite the repeated observations by neurosurgeons (1, 2, 3, 6, 8) that changes in bone not uncommonly accompany such tumors. Pancoast (11), in 1918, and Carman and Davis (5), in 1924, were the first roentgenologists to comment on the value of roentgen rays in the direct diagnosis and localization of these tumors. Pancoast stated "Tumors of the spinal cord cannot be diagnosed by this method, and if by any chance they involve the vertebræ secondarily, the appearance is in no way suggestive of their primary origin." Carman and Davis were the first to record the incidence of direct roentgenographic changes in any series of tumors of the spinal cord. In a series of 119 cases, they elicited roentgenographic evidence of involvement of bone in only three instances (2.6 per cent), from which they concluded that the practical value of direct roentgenologic examination was slight, and that it was impossible to demonstrate tumors themselves by this method. Stimulated by the experience of Adson, and his contention that many of these bony changes should be discernible roentgenographically, and hopeful that improvements in roentgenographic technic had increased

the incidence of their recognition, Adson and I decided to review all the available roentgenograms in the cases of tumor of the spinal cord in which operation had been performed at The Mayo Clinic before 1931. This study (4), presented in detail about two years ago, showed that changes in bone, particularly erosion resulting from contiguous tumor of the spinal cord or associated soft tissues, could be observed roentgenographically in about 20 per cent of all cases.

Because of the significance of these changes and their value in permitting exact localization of the tumor roentgenographically, without additional measures, observations have been continued in all subsequent cases in which tumor of the spinal cord has been suspected. An effort has been made to establish the significant roentgenologic changes associated with the various types of tumors and their incidence under improved roentgenologic methods. The results have been most encouraging, for in that group of cases of tumor of the spinal cord in which operation was performed at The Mayo Clinic between Jan. 1, 1930, and Sept. 1, 1933, osseous changes which directly localized the lesion were observed roentgenographically in 50 per cent. The percentage of cases in which osseous changes were detected varied considerably, as might be expected, with the different groups of tumors. This will be seen from the following figures concerning the more common lesions: neurofibroma, 65 per cent, endothelioma, 11 per cent, ependymal-cell glioma (caudal tumors), 66 per cent, hemangioma and hemangio-endothelioma, 33 per cent, intramedullary tumors (exclusive of ependymal-cell glioma), none.

The significance of this improvement in roentgenologic diagnosis can be appre-

<sup>1</sup> Presented before the First American Congress of Radiology, Chicago, Sept. 25-30, 1933.

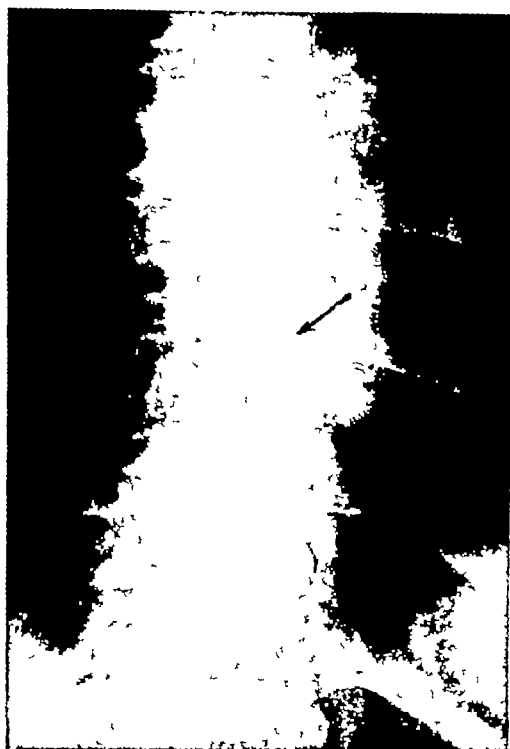


Fig 1 Localized erosion of left pedicle of ninth thoracic vertebra produced by contiguous neurofibroma. Symmetry of the normal pedicles above and below the site of the tumor, may be noted

ciated when it is recalled that similar changes were observed in only 2.6 per cent of Carman and Davis' cases. Confidence in the significance of these changes, which were confirmed by subsequent operation, has enhanced the clinical differential diagnosis of lesions of the spinal cord and has enabled the surgeon in many cases to locate the growth exactly, without the use of a radiopaque oil to establish the diagnosis or the level of the tumor.

#### TECHNIC OF EXAMINATION

In the roentgenographic examination of a patient suspected of having a tumor involving the spinal cord, roentgenograms of the spine taken in the anteroposterior and lateral directions are necessary. These should be supplemented by stereoscopic and occasionally oblique views localized over the suspected site of the lesion. The Potter-Bucky diaphragm, and

a fine-focus tube, are indispensable. Accurate positioning of the tube and patient is essential, since any distortion of the vertebral shadows may be misleading.

In interpretation of the roentgenograms



Fig 2 Erosion of left pedicles of fourth and fifth cervical vertebrae and enlargement of intervertebral foramen produced by dumb-bell-shaped neurofibroma extruding through intervertebral foramen from spinal canal.

the chief concern is with alterations in the structure of the vertebrae or adjoining ribs, and a satisfactory film should show all parts of these clearly. In the past, insufficient attention has been paid to the shadows of the vertebral pedicles and laminae, since these structures usually present evidence of a contiguous tumor before it is discernible in the body of the vertebra. Changes in the shadows of the paravertebral soft tissue may portray extravertebral extension of a neoplasm, hence an exposure, particularly to show these structures, may be necessary if they are not delineated in the roentgenogram of the spine that is made as a routine.

#### CLASSIFICATION

As the title indicates, this paper is concerned only with tumors of soft tissue arising within the spinal canal and it is this group that is of particular interest to the

neurosurgeon For practical consideration by the roentgenologist they may be classified as (1) benign tumors arising from soft tissues within the spinal canal, (2) malignant tumors arising from soft tissues within the spinal canal, and (3) tumors and protrusions of the intervertebral disc, involving the spinal canal

*Benign Tumors Originating within the Spinal Canal*—The most common tumors of this group include neurofibroma, endothelioma (meningioma), hemangioma, angioma, lipoma, and dermoid cyst Ependymal-cell glioma (ependymoma) is included in this group because roentgenologically it resembles a benign tumor All of these tumors involve the bone in a similar manner, that is, by erosion from pressure They have no individual distinguishing roentgenologic characteristic except the neurofibromas, which have a tendency to extrude through an intervertebral foramen, producing an hour-glass tumor partly within and partly without the spinal canal As the tumor enlarges, the adjacent portions of the vertebra are eroded by direct pressure and pulsation of the spinal cord and vessels The margins of the eroded area are sharply demarcated and coincide with the surface of the contiguous tumor or displaced spinal cord These changes rarely occur in the absence of partial or complete block of the spinal canal, unless the tumor is held in contact with the bone by a nerve root or meningeal attachment One or both pedicles of the vertebra at the level of the tumor usually exhibit evidence of erosion before it can be discerned in the laminae or body The pedicle is first flattened on the medial aspect and the cortical bone is rarefied As the tumor grows the surface of the pedicle becomes concave, coinciding with the surface of the mass (Fig 1), and lastly it is entirely destroyed At this stage, if the tumor is a neurofibroma, it may extend along the course of the posterior nerve root and extrude through the intervertebral foramen which it also erodes and enlarges (Fig 2) Later, as the tumor within the canal enlarges, the pedicles of several vertebrae may be involved, and at this

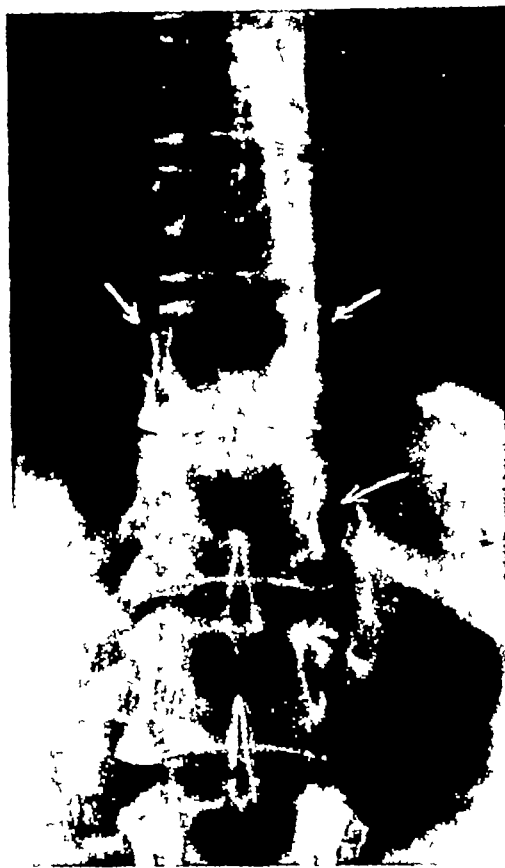


Fig 3 Erosion of pedicles of eleventh and twelfth thoracic vertebrae and right intervertebral foramen produced by contiguous dumb bell-shaped neurofibroma

stage neurologic signs are usually definite (Figs 3 and 4) In the interpretation of changes in the pedicle, one must not be misled by the unilateral pseudo-narrowing of pedicles incident to scoliosis and rotation of the spine Anatomic variations in the size of pedicles should be distinguished from changes resulting from tumor, by involvement in the former case, of several vertebrae and the absence of neurologic signs

Rarefaction of the laminae occurs early but is rarely recognized in the roentgenogram until fairly advanced, because in both the anteroposterior and lateral views the shadows of other structures are superimposed When the tumor is extradural, erosion and rarefaction of the laminae may exactly coincide with the surface and out-



line of the growth Ependymal-cell gliomas may attain large size and produce complete absorption of the contiguous lamina

Erosion of the body of a vertebra is usually recognized later than changes in the

considerable size within the pelvis before the true nature of the lesion is realized Occasionally they may be recognized by the shadows of teeth or bone

Sixty-five per cent of the neurofibromas

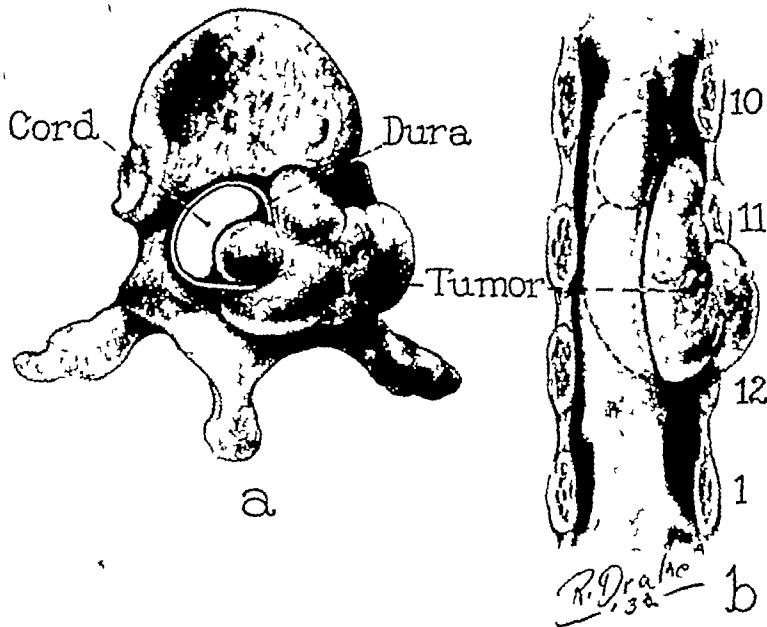


Fig 4 Artist's drawing, showing dumb-bell-shaped neurofibroma *in situ* and relation of tumor and cord to contiguous bony structures which have been eroded by pressure (See Fig 3)

pedicles or laminae The erosion may be localized and discrete, coinciding with the shape of an adjacent tumor, or the body may be uniformly flattened or hollowed out on its posterior surface if the neoplasm is large (Figs 5 and 6) The intervertebral discs and median raphé are particularly resistant to erosion from pressure, and in the presence of large tumors, particularly ependymal-cell gliomas of the cauda, the posterior surfaces of the bodies of the vertebrae exhibit a deep concavity on either side of the median raphé (Fig 7) Occasionally an unusually large benign tumor may erode the vertebra to such a degree that pathologic fracture occurs, with resultant structural deformity Benign antesacral tumors, especially dermoids, may grow to

in this series produced localizing roentgenographic signs in contiguous vertebrae Not uncommonly, such a tumor in the thoracic part of the spine will extrude through an intervertebral foramen into the thorax and produce a shadow that may be confounded with a mediastinal or pulmonary neoplasm (Fig 8) Endotheliomas (meningiomas), because they tend to be smaller, harder, and to grow more slowly, produce osseous changes less frequently (11 per cent of cases) than some other neoplasms of this group The changes which accompany this tumor are usually quite localized Many of these tumors contain calcareous psammoma bodies, and occasionally the calcium is sufficient to be discerned in the roentgenogram, thus making possible



Fig 5 Anteroposterior view, showing erosion of pedicles and lamina of first lumbar and left pedicle of second lumbar vertebrae, produced by intraspinal neurofibroma



Fig 6 Lateral view, showing enlargement of spinal canal and erosion of posterior surface of bodies of first and second lumbar vertebrae. Intraspinal neurofibroma (See Fig 5)

identification of the tumor (Fig 9) According to Kernohan, Woltman, and Adson (9), ependymal-cell gliomas (ependymomas) constitute 68 per cent of all tumors originating in the filum terminale. In this series, 66 per cent of the ependymal-cell gliomas had produced erosion of bone, hence, the presence of such a tumor is suggested when significant osseous changes are discerned in the lumbosacral region. Early recognition of these changes may be obscured by the presence of spina bifida.

Angiomas and hemangiomas produce secondary changes in bone similar to the changes caused by other tumors in this group, but the rarefied bone is likely to be spongy and to bleed freely. They seem to have a predilection for the thoracic region, especially as indicated by this series.

*Malignant Tumors Arising from Soft Tissues within the Spinal Canal*—Tumors of this group include both primary and metastatic lesions. The intramedullary tumors, particularly the gliomas with the exception of ependymal-cell gliomas which already have been considered, do not commonly involve the vertebrae secondarily.

Since these tumors originate within the spinal cord, serious neurologic signs usually occur long before the growth has expanded the cord sufficiently to erode the surrounding bone. The other tumors, consisting chiefly of various forms of sarcoma, lymphosarcoma, malignant hemangio-endothelioma, and metastatic growths, destroy the surrounding vertebrae by direct infiltration, and thereby produce the well-recognized roentgenologic picture of malignant disease in bone. Extension into the paravertebral tissues is not uncommon. Rarely, from the secondary changes in bone, can the primary or metastatic nature of malignant tumors of soft tissue be predicted except as similar changes may be observed in other regions of the spine.

*Tumors and Protrusions of the Intervertebral Disc Involving the Spinal Canal*—



Fig 7 Erosion of fourth and fifth lumbar vertebrae and sacrum produced by pressure from large intraspinal ependymal-cell glioma. The margins of the eroded bone are sharply defined.

These are termed by Elsberg "ecchon-droses" (7), and, in his experience, they constitute 14 per cent of tumors of the spinal cord. They are most common in the cervical portion of the spine. Two types should be distinguished: (1) true tumors, comprising chondromas, fibrochondromas, and fibromyxochondromas, which usually grow rapidly in the line of least resistance toward the spinal cord which they compress, and (2) traumatic prolapse of the intervertebral disc into the spinal canal. Because of their cartilaginous nature these masses are not themselves visible in roentgenograms, however, the tumor, because of its growth, may widen the posterior portion of the intervertebral space and even erode contiguous bone. In the traumatic variety, the intervertebral space is narrowed because of

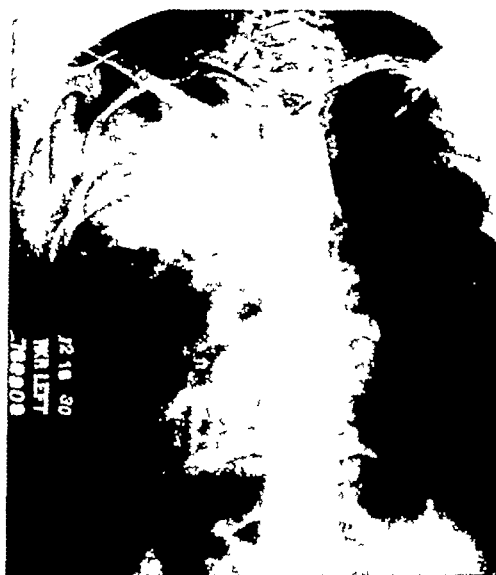


Fig 8 Dumb-bell-shaped neurofibroma with extensive intrathoracic extension. Note destruction of left pedicle of third thoracic vertebra, enlargement of intervertebral foramen and erosion of third left rib posteriorly, with widening of intercostal space.

previous compression and prolapse of a portion of the disc. Secondary thickening of the contiguous vertebral margins may occur. Calcification and even ossification of these intraspinal protrusions have been noted by Schmorl (12). In doubtful cases, injection of a radiopaque oil into the subarachnoid space may disclose the situation of the lesion.

#### DIFFERENTIAL DIAGNOSIS

Since the symptoms of tumor of the spinal cord are largely the result of compression of the cord, nerve roots, or both, differential diagnosis of these lesions, by the roentgenologist, involves the consideration of any deformity or disease-process that is capable of producing compression of the cord or nerve roots. For practical consideration, the conditions other than those previously mentioned may be listed as (1) inflammatory disease of the spine and meninges, (2) benign tumors of the vertebrae, (3) malignant tumors of the vertebrae, (4) non-neoplastic lesions of the



Fig 9 Calcified intraspinal dural endothelioma (meningioma) overlying shadows of fourth and fifth thoracic vertebrae

vertebrae, and (5) congenital anomalies of the spine

In considering the distinction of these conditions from osseous changes associated with tumors of the spinal cord it is important to bear in mind that the bone is only secondarily involved in the case of tumor of the spinal cord and that the changes are erosive if the lesion is benign, and infiltrative if the growth is malignant. The extent of destruction depends on the size of the contiguous tumor of soft tissue. It is noteworthy that, in this series, no tumor of the spinal cord had caused secondary proliferative changes in the vertebrae that could be discerned roentgenographically, hence, a vertebral lesion which exhibits osteogenic properties is, in all probability, not the result of a contiguous tumor of the spinal cord. The so-called spongy hypertrophy of bone sometimes encountered by neurosurgeons, contiguous to a tumor, has not been demonstrated roentgenographically in my experience. This is probably a change resulting from atrophy of bone secondary to pressure from the neoplasm or to circulatory change in the bone resulting from irritation by the mass.

*Inflammatory and Degenerative Disease of the Spinal Cord and Meninges*—Exam-



Fig 10 Destruction of sacrum by chordoma

ples of vertebral involvement secondary to these conditions are exceedingly uncommon. I have observed one case in which erosion of a pedicle was produced by a contiguous localized cyst in a case of chronic cystic arachnoiditis. The osseous change was identical to that which might have been caused by a contiguous benign neoplasm. Generally speaking, these lesions do not involve the vertebrae and are discerned only after injection of radiopaque oil into the subarachnoid space.

*Benign Tumors of the Vertebrae*—These tumors include osteomas, osteochondromas, chondromas, fibrochondromas, giant-cell tumors, and hemangiomas. All of these tumors which may involve the spinal cord by secondary compression, exhibit the same roentgenologic characteristics in the vertebrae as in the skeletal system elsewhere. The osteomas and osteochondromas, which are osteogenic in nature, should not be confounded with the changes caused by a tumor of the spinal cord. The chondromas and fibrochondromas may

arise from the central portion of a vertebra and thus produce early signs of compression of the cord. Since they erode the bone directly by pressure and produce a sharply defined defect in the vertebra, they may easily be confounded roentgenographically with the changes of a benign tumor of the spinal cord, particularly if the growth has originated in that part of the vertebra that is close to the canal. Fortunately, these tumors are rare and need not often concern the roentgenologist.

*Giant-cell tumor* usually involves the body of a vertebra, although the bony processes are not uncommonly affected. This multilocular cystic lesion, primary within a vertebra, should be readily distinguished from the localized erosion of a benign tumor of the spinal cord. In the latter instance, the changes are contiguous to, and represent an enlargement of, the spinal canal, the remote parts of the vertebra being normal. In the case of giant-cell tumor, the remote portions of the vertebra are usually involved and the bony shell delineating the wall of the spinal canal generally can be identified. Collapse of a vertebra is not uncommon in giant-cell tumor, and under such circumstances the usual characteristic roentgenographic appearance may be obscured. The resulting neurologic symptoms, however, are out of proportion to those which accompany a tumor of the spinal cord that is large enough to cause collapse of a vertebra.

*Hemangioma* of a vertebra produces irregular absorption and thickening of the trabeculae of the bone, giving its structure a coarse, honey-combed appearance. This is easily distinguished from the localized erosion caused by a tumor of the spinal cord.

*Malignant Tumors of the Vertebrae*—Tumors of this type, that secondarily involve the spinal cord, include all lesions, both primary and metastatic, that are found elsewhere in the skeletal system. The more common are sarcomas, myelomas, endotheliomas, metastatic carcinomas, and hypernephromas. The roent-

genologic characteristics of these lesions are too well known to warrant consideration here. Except in the presence of involvement of multiple vertebrae, indicating metastatic disease, it is frequently impossible to decide whether or not the malignant disease started in the vertebra and involved the cord and surrounding tissue secondarily, or *vice versa*. The chordomas are included in this group since they arise from remnants of the notochord in the vertebrae or sacrum, and for roentgenologic consideration are essentially tumors of bone. They most commonly arise in segments of the sacrum, where they produce extensive malignant destruction and even invade the ilium and pelvic cavity (Fig. 10). They are closely imitated by metastatic malignant growths and are commonly confounded with large, lumbosacral ependymal-cell gliomas. The latter, however, should be readily distinguished by the marked difference in the type of secondary destruction of bone.

*Non-neoplastic Lesions of the Vertebrae*—Proliferative changes in the laminae, spinous processes, pedicles, and bodies, sometimes resulting in the condition that is referred to as hypertrophic osteitis, may involve one or several vertebrae. They generally represent reactions to previous trauma, localized infection, so-called hypertrophic arthritis, or spondylitis deformans. They vary in degree from localized hypertrophy, encroaching on the spinal canal, to massive fusion of several spines and laminae. Proliferative changes about the margins of the lateral articulations are not uncommon. Spondylitic exostosis localized at the margins of one or a few contiguous vertebral bodies, the rest being normal, has been described as a frequent accompaniment of tumor of the spinal cord (10). Such changes, however, in my experience, have not occurred consistently enough to warrant such a statement. Proliferative changes in bone may occasionally develop after operative procedures on the vertebrae, but they rarely extend into the spinal canal and produce compression of the cord.

Compression fracture and fracture dislocation may cause development of bony callus, and may give rise to late signs of compression of the cord that simulate tumor of the spinal cord. A fracture may not be clearly revealed in the original roentgenogram, but as callus is formed the site of the injury becomes obvious.

Primary infections of the vertebræ, such as tuberculosis, osteomyelitis, actinomycosis, coccidioidal granuloma, and so forth, may result in abscess within the spinal canal and cause symptoms of tumor. The destructive areas in the vertebræ, together with involvement of the intervening intervertebral disc or discs, should suggest the presence of an infectious process since these structures are particularly resistant to invasion by tumor.

*Congenital Anomalies of the Vertebræ* — These are common, but the actual anomaly itself is not likely to be confounded with the changes secondary to tumor, since evidences of erosion or infiltration are naturally not present. The anomaly, however, may obscure early recognition of a coincident neoplasm, particularly in the lumbosacral region, where the existence of spina bifida frequently will mask recognition of early erosive changes in the lamina.

Records in The Mayo Clinic, to March 1, 1932, disclose that 394 patients have been operated on for tumors compressing or invading the spinal cord (3). Ninety-seven (25 per cent) were situated extradurally, 196 (50 per cent) were situated subdurally but were extramedullary, and 101 (25 per cent) arose from the spinal cord or filum terminale (intramedullary). A study of the entire group of 394 cases emphasizes the fact that the greater proportion of intraspinal tumors are removable.

Since our experience has shown that 50 per cent of these tumors may be localized by the primary roentgenogram, without the use of additional aids, we believe that this method of examination should occupy a prominent place in the diagnosis of these neoplasms, which, if recognized and removed early in their development, can be permanently cured.

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# STANDARDIZATION OF ROENTGEN DOSAGE BY MEANS OF METHYLENE BLUE II<sup>1</sup>

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IN previous publications (1) we have discussed the effect of roentgen irradiation on solutions of certain colored organic substances. It was shown in particular that methylene blue was quite rapidly discolored. The amount of color change could be measured accurately by means of a spectro-photometer and could be used for determination of roentgen dosage. The advantages of such a method were also considered. We have continued the attempt to make the method practical. In order to obtain a wide field of usefulness it seemed important to so arrange it that a small amount of solution would be needed and that the solution would be surrounded exclusively by organic material during the exposure.

During these experiments the solutions were buffered so that the PH was kept constantly at 6.8.

*A Solutions*—A stock solution is made up by dissolving 0.05 gr of purified methylene blue and making up to 500 c.c. volume with boiled distilled water, giving a concentration of 0.1 mg per cubic centimeter.

The final solution of methylene blue used for irradiation is made up by dissolving 2.969 g of  $\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$  and 2.2695 gr of  $\text{KH}_2\text{PO}_4$  in about 300 c.c. boiled distilled water. A calculated amount of the methylene blue stock solution (13.5 c.c.) is added and the solution then made up to 500 c.c. volume with boiled distilled water, giving a concentration of 0.0027 mg per cubic centimeter. This concentration may have to be slightly adjusted to give the desired absorption. The solution has to stand one week before it can be used. How long it will keep is as yet a

question—it has been found in good condition at the end of three months but has to be tested if left for a longer time.

*B Absorption*—A spectro-photometer was used for determination of the concentration before and after the exposure to roentgen rays. The absorption was measured at 6,700 Å U, as the maximum absorption in the visible region takes place at this wave length. The smallest container (absorption tube) that seemed practical to use with our spectro-photometer measured 2 cm in length and 1 cm in inside diameter. Containers holding about 2.5 c.c., therefore, had to be used during the roentgen irradiation, and they had to be made from organic material. In order to obtain a suitable color intensity when a 2-cm-long absorption tube was used, the concentration of methylene blue had to be approximately 0.0027 mg per c.c. of water. The final concentration was adjusted so that the solution had an extinction coefficient of 0.754. An experimentally obtained curve showing the relation between the dose and the color change must be used when the method is applied for standardization.

*C Containers*—It required much experimentation before a method of making suitable containers was developed. Among the substances tested, superlawax and parlodion were found to be suitable, as they did not influence the color change of the methylene blue. When the solution was kept in shallow rectangular grooves in a block of superlawax, fair results were obtained but the errors were too large, probably due to small amounts of impurities. With such a large surface exposed to the air, too much dust may have gathered before the surface could be covered, it was found that a small amount of dust deliberately added had a pronounced influence.

<sup>1</sup> Read before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1 1932.

Parlodion can easily be dissolved in a mixture of alcohol and ether, 50 per cent of each. By coating the inside of a container (for instance, a test tube) with this solution and letting it dry, a thin coat of parlodion remains which may be removed. However, a better procedure to obtain a sealed container has been adopted. An ordinary water soluble gelatin capsule No. 13 (for veterinary use) is used as the mould. A smoothly running but fairly thick and sticky solution of parlodion is poured into the two halves of the capsule. Excess parlodion is poured out and the capsules are turned around continuously until the solution does not run any longer, whereupon they are left to dry for some minutes and a second coating is added in a similar manner. Seven such coats seem to be needed. After practically all the ether and alcohol has evaporated (in about three days), the capsules are dissolved in water and the parlodion is washed with cleaning solution and distilled water. The methylene blue solution is poured into these capsules and exposed to the roentgen rays. It was found that the first containers used became colored from some absorbed methylene blue, which meant that the solution became weaker and the readings indicated a color change even without any irradiation of the capsules. This source of error was overcome by adding a very small amount of concentrated hydrochloric acid to the alcohol and ether solution before the parlodion was dissolved. Even with the present method of making the containers, it is necessary to test them before they are acceptable. The test consists in filling them with the methylene blue solution and exposing them to roentgen rays. If successive exposures give the same amount of change, or if the change is the same as in already tested capsules, then they are ready to use. These capsules can be left filled with solution for a week in a room without showing any leakage or any other effect on the solution. When they are transported from one place to another they may, however, develop a leak, prob-

ably due to temperature variations or to violent shaking. They are, therefore, dipped in melted paraffin and thus supplied with a thin protective coating before being sent away. When the capsules are not in use they should be kept in distilled water and protected from exposure to direct sunlight.

*D. Measurements*—The method has not been tested enough as yet to permit us to state whether or not it is practical for comparison of dosage at different places but we believe it may prove to be of value. The accuracy is not as great as we would like to see it, but as the procedure is very simple this method may be used at certain intervals at a great number of therapy installations to obtain a fair comparison between the dosages used. We wish to emphasize again the advantage of thus comparing the total amount of radiation absorbed at the surface or at certain "depths" by an organic solution under conditions which are similar to those during treatments and which limit the exposed parts to organic compounds and water.

In order to obtain a standardization curve, a number of exposures have been made under the following conditions: 200 K V peak, 30 ma, 0.5 mm copper and 1 mm aluminum filter were used. The containers were placed in small grooves in a block of paraffin, surrounded (but not covered) with paraffin so that the full amount of scattering was obtained from a  $20 \times 20$  cm field and from a layer 14 cm thick. The distance from target to the surface of the paraffin and also to the top of the capsules was 50 centimeters. The number of roentgens per minute as measured in air with a Victoreen r meter (No. 378) amounted to 82. Since this instrument showed a considerable amount of leakage when the roentgen machine was going, it was completely surrounded by lead except for the small ionization chamber, and in this manner the leakage was made negligible. The half value layer in electrolytic copper was found to be 1.0 millimeter.



TABLE I

Decomposition of methylene blue by roentgen irradiation 200 K V, 30 ma, 50 cm distance target to container, 0.5 mm Cu + 1 mm Al filter Field 20 X 20 cm paraffin 14 cm thick, 15 min gives approximately 1,200 roentgens (measured in air)

Time of radiation	Percentage of decomposition	Time of radiation	Percentage of decomposition
15 min	31	45 min	49
15 min	31	45 min	51
15 min	31 5	45 min	52
15 min	31	45 min	51
15 min	30	45 min	51
15 min	31 5	45 min	53
15 min	30	Average	51
Average	31		
30 min	43	1 hr	62
30 min	46	1 hr	58
30 min	43	1 hr	59
30 min	43	1 hr	61
30 min	44	1 hr	62
30 min	43	Average	60 5
30 min	44		
Average	44		
		1½ hr	69 5
		1½ hr	70 5
		Average	70
		2 hr	75

TABLE II

Time of radiation	Percentage of decomposition
10 min	22
10 min	23
10 min	23
10 min	24
10 min	21
10 min	23
Average	22 5
5 min	14
5 min	16
5 min	13
5 min	11 5
5 min	11
5 min	11 5
Average	13

The results of the measurements are shown in Figure 1 and Tables I and II. Each figure under "percentage of decomposition" in these tables represents the average of at least three tubes exposed at the same time. The difference in the decomposition determinations between the individual tubes, irradiated together for 15 minutes, runs as high as  $\pm 5$  per cent. The readings can be made with greatest accuracy when about 30 per cent of the methylene blue has been destroyed, an

amount of change which requires 15 minutes, or, according to the roentgen meter (No 378), 1,200 roentgens to obtain. This corresponds to 150 per cent of our erythema dose. When the capsules are mailed to other offices they should be exposed, therefore, to approximately 1,200 roentgens (as measured in air). The readings corresponding to this part of the curve show an individual variation of about  $\pm 5$  per cent in dosage. The errors when comparing doses should not exceed, therefore, this amount, as three capsules are supposed to be exposed at a time and at least two of them ought to come back in good shape.

The following procedure is now used. A cardboard box 8 X 12 X 3 cm is filled with melted paraffin. After this has hardened, five grooves are made by means of a heated metal tool (fastened to a handle) of the same size and shape as the capsules. These grooves are numbered and in them are placed the paraffin-sealed containers filled with the methylene blue solution. Figure 2 shows the distribution. The box is covered and wrapped in cotton. A note of instructions is added and the package is sealed and mailed by special delivery.

#### INSTRUCTIONS READ THIS BEFORE OPENING THE PACKAGE

1 Keep the containers in the dark except during the exposure, as the methylene blue is slowly discolored by light and especially by ultra-violet radiation.

2 The exposures to x-rays ought to be made and the package returned as soon as possible, preferably within 24 hours.

3 Containers No 1 and No 2 in the outside grooves should be removed before any exposure is made. In order to obtain full amount of scattered radiation the two empty grooves should be filled with water, and the small paraffin block placed on a larger block and also be surrounded with, but not covered by, paraffin. The total thickness of paraffin should be at least 10 centimeters. A 20 X 20 cm field should be used.

4 Containers No 3, No 4, and No 5 should be exposed under the desired conditions (we propose 200 K V, 50 cm distance from target to top of container, 0.5 mm copper plus 1 mm aluminum filter)

if the readings of their solution do not check with the previous readings, no satisfactory information can be obtained and this particular shipment would be a failure

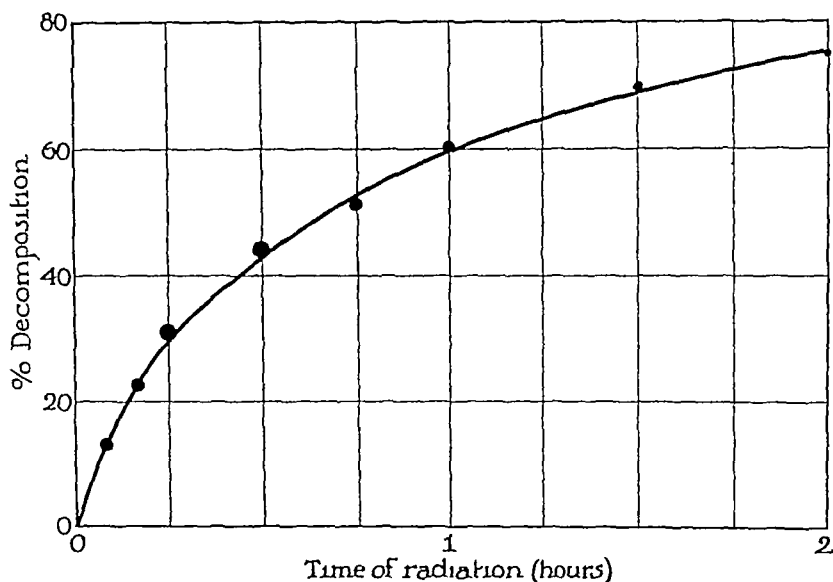


Fig 1 See text

The dose given should be about 150 per cent of an erythema dose (1,200 roentgens as measured in air without back-scattering) The dose should in any case lie between 120 and 250 per cent S E D

5 After the exposures have been made the grooves should be dried out and the containers replaced in their respective pockets and the box mailed back The amount of exposure given and the arrangement used should be written down and included in the package

When returned, the tubes are immediately inspected with care for damage Even a slight amount of evaporation from a tube makes it necessary to discard its solution If the tubes are covered with a filter paper during the entire trip and some solution leaks out, then this paper becomes stained A more accurate test for leakage or evaporation is to weigh the tubes before and after their journey If neither of the two unexposed tubes are intact or

It is evident that measurements of this type can be carried out only where spectrophotometers are available and that it requires some training to obtain satisfactory accuracy in taking the readings With the description given in this and two earlier papers it should be relatively easy to prepare the solutions and the containers in a laboratory and to duplicate dosage measurements according to the method here outlined

It is evident that the capsules with the solution can be used in several different ways to measure dosage distribution Our first attempt is, however, to use them as described above, to facilitate standardization of different machines

#### SUMMARY

1 A method of using a water solution of methylene blue to measure roentgen dosage is described

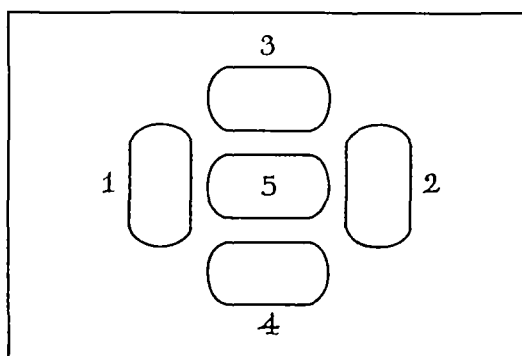


Fig 2 Distribution of capsules in paraffin block.

2 A spectro-photometer is used to determine the color change

3 The solution is buffered to a PH of

6 8 The exact method of preparing this solution is described

4 Small capsules of parlodion are used as containers and the process of making them is described

5 The manner in which these capsules are exposed is explained

6 A standard curve showing the relation between the amount of exposure and color change has been determined experimentally

7 The solution can be sent by mail to any part of the country for exposure and returned to the laboratory for measurements

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# A COMPARISON OF PHOTOGRAPHIC AND IONIZATION MEASURES OF RADIATION QUALITY

By OTTO GLASSER, PH D, and L E ROVNER, B S, *Cleveland Clinic Foundation, Cleveland, Ohio*

## I THE PHOTOGRAPHIC DETERMINATION OF THE HALF VALUE LAYER

AMONG the many methods for obtaining a description of the quality, or absorption characteristics of a roentgen-ray beam, one that in recent years has gained more and more attention is the photographic determination of the half value layer. First suggested by the work of Christen (1), the Swiss mathematician and physician, and preceded by such devices as the Benoist penetrometer (2), the idea of a photographic method has been developed up to its present frequent use in roentgenology.

The half value layer describes roentgen radiation quality in terms of that thickness of an absorbing material, such as copper or aluminum, which reduces the incident intensity of a beam by 50 per cent.

Photographic determinations of the half value layer of a given roentgen-ray beam are ideally accomplished by the simple procedure of matching a photographic darkness, produced upon a film by a beam of half intensity, with the darkness under a metal filter stairs exposed to the full intensity of radiation.

There are several apparent recommendations for such a method of measurement: a group of intensity measurements can be obtained at one time, the film acts as a recording medium, yielding a permanent record of intensities which may be expressed relatively by the film darkening, the method is simple, and certainly it is inexpensive.

Meyer (3) has developed this process of half value layer measurements, his work also mentions the use of the stair filter with a 1.0 mm copper strip to derive copper-aluminum equivalents photographically.

In the procedure generally followed, a suitable film or plate in a light-tight con-

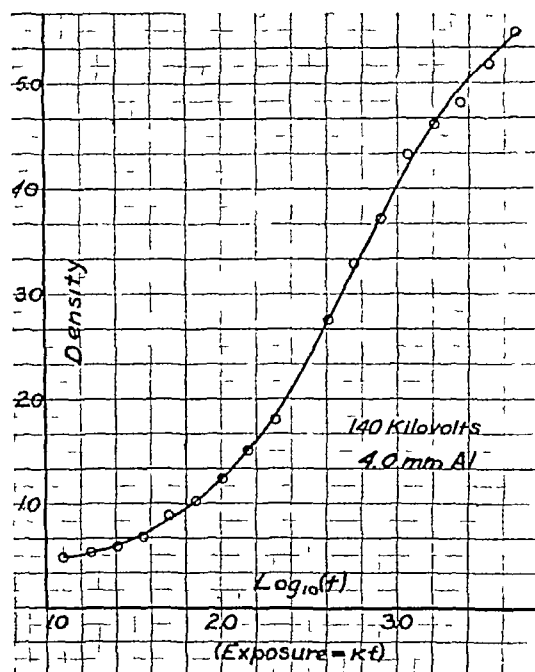


Fig 1 Hurter and Driftfield curve

tainer is covered by a strip of lead, and by stair filters either of aluminum or copper, or both. This device is exposed to the roentgen-ray beam. At one-half the necessary exposure time, the beam is cut off, and the lead strip is removed without disturbing the stairs. The film is then exposed again for another interval of one-half time, so that the region under the stairs has received one full exposure, while that area under the lead has received one-half of the exposure.

After proper development, those regions under the steps in which the photographic opacity is the same as that of the half-exposure-time strip are determined, and the step thicknesses corresponding to those areas are designated as half value layers.

It seemed worth while to make a study comparing the half value layers obtained

from photographic observation with those derived from the more generally accepted ionization absorption measurement of radiations produced by the same conditions

additions in exposure time give less and less increase in the amount of reduction of the silver on the film

The toe portion of the curve is defined

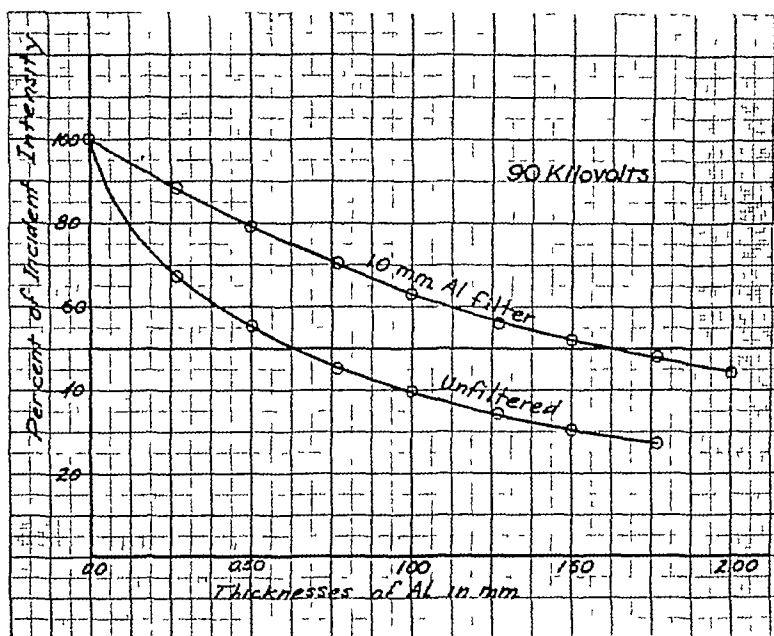


Fig 2 Ionization absorption curves for 90 kilovolts

## II RESPONSE OF THE PHOTOGRAPHIC EMULSION TO ROENTGEN RAYS

For measurements of any radiation by photographic methods, it is necessary to know the characteristics of response of the emulsion to the radiation. Such information is required in determining the relationship of radiation intensities to film darkening and in defining the limits of proper exposure.

The Hurter and Driffield curve for photographic emulsions (Fig 1) describes their characteristics of action in response to actinic radiations on a time scale. From the curve it may be seen that increases in exposure time, with radiation of a fixed intensity, first produce only a gradual increase in the density of darkening on the film. Next, a uniformly increasing density occurs, following which a saturation value of the darkening is reached after which

as the underexposed region, in the straight line interval the density is directly proportional to the logarithm of the exposure, and here conditions of correct exposure exist. (The slope of the straight line portion is a measure of the contrast of the lights and darks upon the emulsion.) Finally, densities occurring on the saturation arch are in the overexposed region.

For the Hurter and Driffield curve, photographic density is plotted against  $\log_{10}$  of exposure, here the density of blackening of a film is defined as  $\log_{10} \frac{i_0}{i_t}$ . The

quantity  $\frac{i_0}{i_t}$  (the reciprocal of transmission,  $T$ ) is the opacity,  $O$ , of a film, its darkness as seen to the eye,  $i_0$  and  $i_t$  are thus the incident and transmitted light intensities observed for an area of the developed emulsion.

The opacity of a film can be obtained from photometric measurements, and from this value the density is derived. In the case of an area allowing 1 per cent of inci-

Until 1923 it was thought that the Hurter and Driffield curve for roentgen-ray action upon the photographic emulsion had no saturation value, it was assumed to be

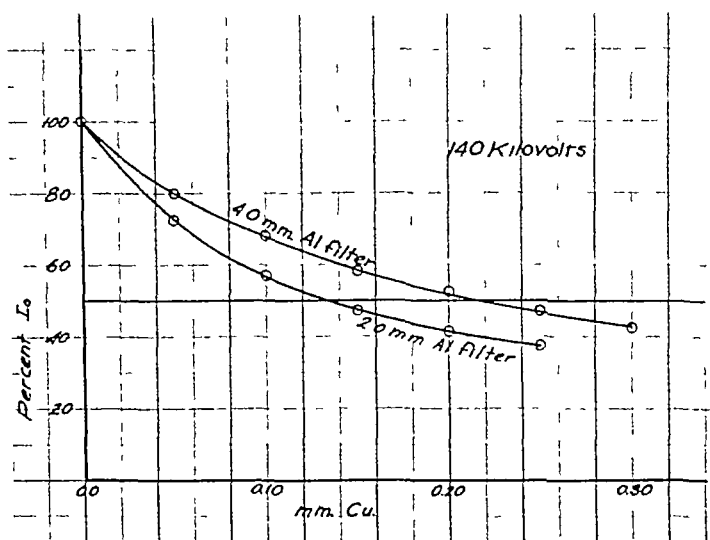
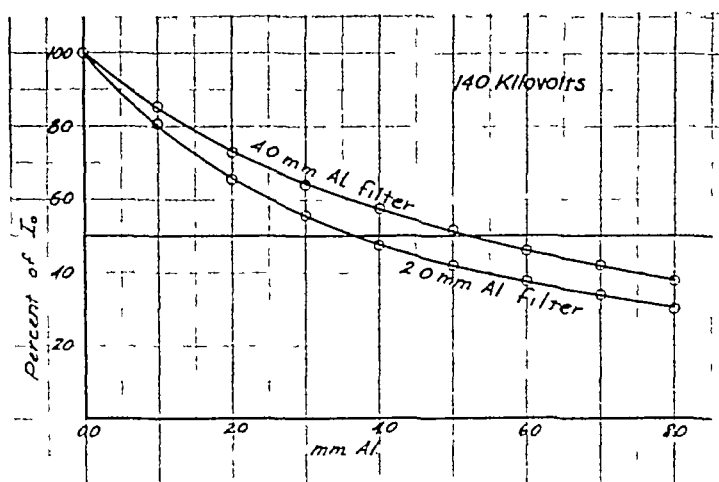


Fig 3 (Upper) Ionization absorption curves for 140 kilovolts

Fig 4 (Lower) Ionization absorption curves for 140 kilovolts

dent light to pass, the transmission is then  $1/100$ , the opacity, 100, and the density,  $\log_{10} 100$ , is 2.0

The exposure, the quantity plotted as abscissa in the Hurter and Driffield curve, is described as the product of the intensity,  $I$ , and time,  $t$ , of application of the beam producing the darkness

exponential throughout. At that time, Jones (4), of the Eastman Laboratories, produced a densitometer measuring densities as high as six. Studying the response of the process plate to x-rays, Jones obtained a typical Hurter and Driffield curve occurring at high densities.

An assumption that underlies the photo-

graphic determination of the half value layer is that the area exposed for one-half time will be as dark as though it were irra-

be unity. The investigations of Glocker and Traub (5), and Bouwers (6) into the value of the constant  $p$  in the  $\lambda$ -ray region

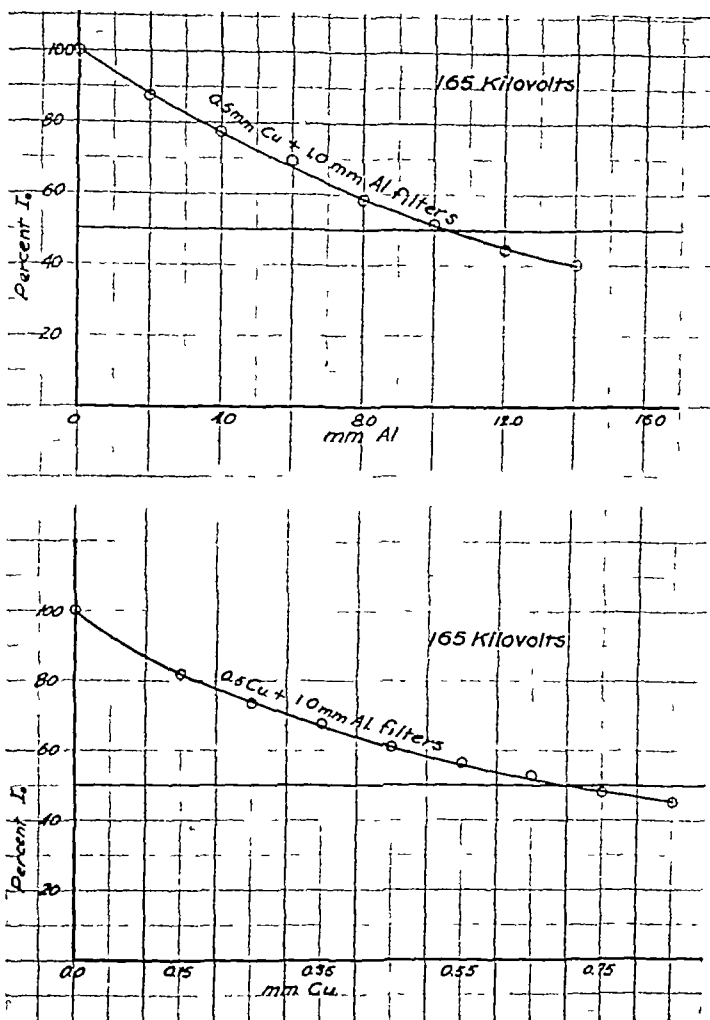


Fig 5 (Upper) Ionization absorption curves for 165 kilovolts

Fig 6 (Lower) Ionization absorption curves for 165 kilovolts

diated by  $\lambda$ -rays of one-half the intensity that is,  $(\frac{1}{2}I) \propto t = I \propto (\frac{1}{2}t)$ . This and similar relations are grouped under the reciprocity law, which is familiar to the biologist as the Bunsen-Roscoe law. The most general statement of this relationship is  $D = f(I^p)$ .

It is easily seen that for these observations the value of the exponent  $p$  must

give values approximating unity, that is  $p = 0.98 \pm 0.01$  and  $p = 0.99 \pm 0.02$ , respectively. For a ratio of intensities within a range of 1 to 10, the deviation from the reciprocity law is less than 5 per cent. The constant,  $p$ , was assumed to be unity in interpreting the Hurter and Driffield curve.

TABLE I

Condition	Kilovoltage	Filtration
1	90	None
2	90	1 0 mm Al
3	140	2 0 mm Al
4	140	4 0 mm Al
5	165	0 5 mm Cu + 1 0 mm Al

(Tube current of 4 0 ma throughout)

### III APPARATUS AND EXPERIMENTAL PROCEDURE

In the process of the study, three distinct groups of equipment were used x-ray, photographic, and densitometric

A Westinghouse Quadrocondex apparatus was used to supply current to a 200-kilovolt Coolidge deep therapy tube. Intensity and absorption measures of the x-ray beam were made with a standard air ionization chamber described by Glasser (7) for the following five conditions commonly met in roentgen therapy (Table I)

At each of the five conditions, the ionization measurements were taken for a series of filtrations in order to obtain percentage intensity curves from which the half value layers were derived

To bracket the photographic measures with a check upon the quality output of the x-ray tube, a series of ionization absorption measures was run before and after the group of photographic observations. Curves of the second series are shown in Figures 2, 3, 4, 5, and 6

For the photographic operations, the Eastman 5 X 7 inch single coated, safety process film was chosen because of its slow action and high contrast obtainable. It was inclosed in the regular cardboard x-ray cassette from which the lead backing was removed to minimize secondary radiation (Fig 7)

In the procedure, the cassette was placed in a special holder at a focal distance of one meter. To avoid scattered radiation, a system of lead diaphragms was so arranged that the beam swept through the cardboard and film without striking the carriage or film support (Fig 8)

TABLE II —EXPOSURE TIMES

Condition	1/2 Time
1	30 sec
2	1 min, 10 sec
3	1 min, 10 sec.
4	1 min, 30 sec
5	2 min, 15 sec

TABLE III<sup>2</sup>

1 0 mm Al Steps			0 1 mm Cu Steps	
Step	Step density	H V D	Step density	H V D
1	2 37	2 07	2 32	2 17
2	2 30	2 08	2 12	2 19
3	2 22	2 10	1 93	2 17
4	2 13	2 13	1 77	2 15
5	2 11	2 12	1 64	2 13
6	2 04	2 16	1 53	2 13
7	2 00	2 18	1 43	2 14
8	1 96	2 18	1 32	2 10
9	1 91	2 17	1 21	2 06
10	1 87	2 20	1 13	2 06
11	1 78	2 20		
12	2 17	2 17		

<sup>2</sup> Measurements by Dr Wilsey

For developing the film, a large thermostat bath was set up, and specially prepared glass tubes were used as developing vessels, operated while immersed in the thermostat bath. The tubes were equipped with smooth glass pistons to provide a positive agitation of the developer about the emulsion. Also suspended in the thermostat bath were two large rubber tanks, one containing water, the other, the fixing solution.

The choice of a developer for accurate physical measurements of film darkening is restricted to that of a non-staining, low-fog-production type. Stain developers, such as pyrogallol, produce some of the blackening upon the film by their property of turning dark after oxidation in the development process. Since this stain darkening may be a variable factor, it is best to avoid such a type of developer.

An amidol developer was chosen because of its stainless developing property, its low-fog-production, and the ease with which it could be prepared from a stock mixture. Approximately 300 c c of full-strength developer was used for two films and then discarded. The fixing bath was of the usual acid hypo type.



graphic determination of the half value layer is that the area exposed for one-half time will be as dark as though it were irra-

be unity. The investigations of Glocker and Traub (5), and Bouwers (6) into the value of the constant  $p$  in the x-ray region

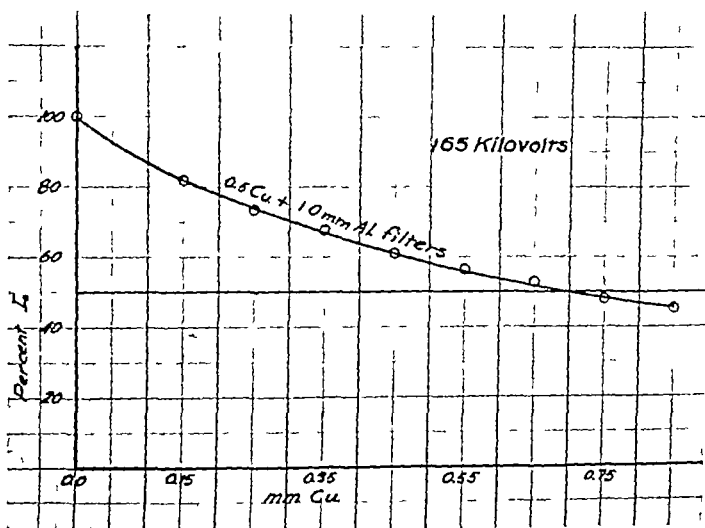
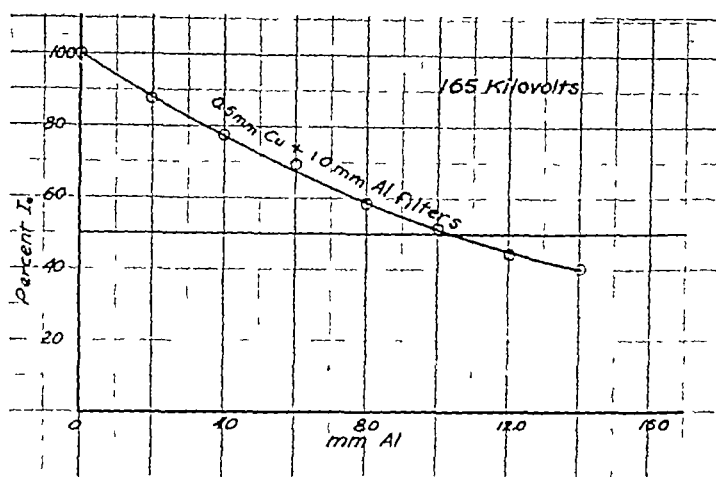


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Fig 6 (Lower) Ionization absorption curves for 165 kilovolts

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possibility of error in a visual method, by comparing a step directly with only the adjacent half value density, is apparent

To arrive at the best values of photographic half value layers, densitometer measurements were made giving an average of the half value density, and an interpolation was made from the intercept of

TABLE IV

Condition	Half Value Layers			
	Ionization		Photographic	
	Aluminum	Copper	Aluminum	Copper
1	0.63 mm		1.4 <sup>1</sup> <sub>1</sub> mm	
2	1.60 mm		2.5 <sup>1</sup> <sub>2</sub> mm	
3	3.67 mm	0.136 mm	4.8 <sup>1</sup> <sub>4</sub> mm	0.20 mm
4	5.23 mm	0.231 mm	6.1 <sup>1</sup> <sub>5</sub> mm	0.24 mm
5	10.4 mm	0.666 mm	11.0 <sup>1</sup> <sub>5</sub> mm	0.52 mm

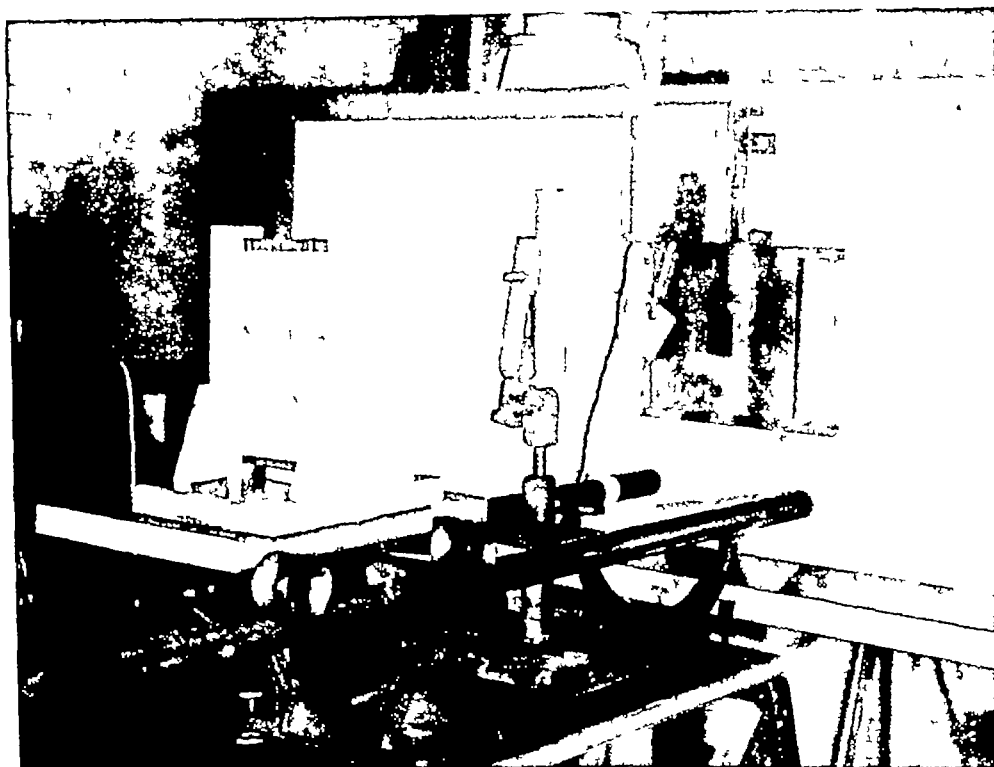


Fig. 8 Film and shutter arrangement for photographic method

this value with a curve of step densities plotted against step thicknesses<sup>1</sup>

Greatest stress, however, was laid upon the use of direct visual comparison, as this is the method used in practice. Direct comparisons for the half value layer were made by placing the film upon a slit cut in dark paper covering a ground glass diffusing screen.

<sup>1</sup> We are indebted to W. E. Forsythe, of the Nela Park Laboratories of Cleveland, Ohio, as well as to N. Rashevsky, of the Westinghouse Electric and Manufacturing Company Research Laboratories, Pittsburgh, Pa., M. J. M. Schwarzschild, of Beth Israel Hospital, New York, and R. B. Wilsey, of the Eastman Kodak Company Research Laboratories, Rochester, N. Y., for their kindness in making various density measurements of our films.

#### IV EXPERIMENTAL RESULTS

The mean values for the half value layers obtained photographically are compared with those obtained by ionization methods in Table IV and in Figure 9.

In Table IV and the curves of Figure 9 only the aluminum half value layers are the result of eye comparison. Copper values shown are the average of the photometer readings alone, for the visual copper half value layers for conditions 3 and 4 in Table I were the same 0.20 mm, since no interpolations were possible. The visual copper value for condition 4 is 0.54 millimeter.

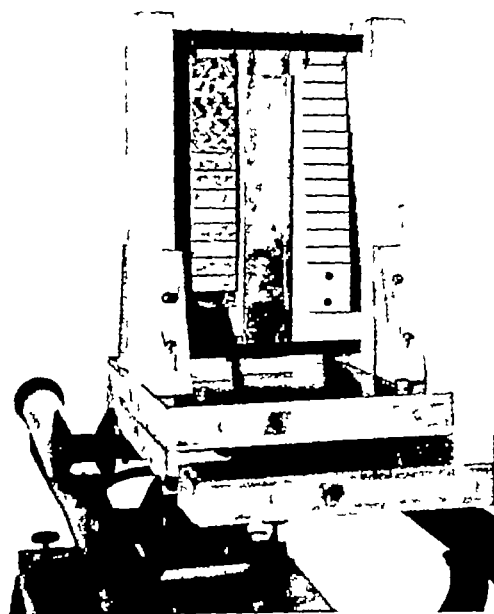


Fig 7 Film and stairs for measuring absorption by photographic method

Here another advantage of the amidol was that it was neutral chemically, so that films could be transferred from the developer directly into the acid hypo bath without an intermediate washing, and thus the time of development could be regulated more closely.

In preparing for the photographic measurements of the half value layer, data for Hurter and Driffeld curves for each of the five conditions were first obtained. For each condition, areas of a single film were exposed to a beam held at constant intensity. The time intervals of exposure were increased in geometric progression by the ratio of the square root of 2. Timing was performed by a hand shutter and the focal distance was so arranged that a time interval of no less than twenty seconds was used on the straight-line portion of the curve.

After the Hurter and Driffeld curves had been established, a trial exposure of the stair-bearing films was made under controlled conditions, and the times of exposure for the various filtrations were roughly determined so that the half value densi-

ties fell within the straight-line portion of the curve, the region of correct exposure. It was found that half-time exposures of between 5 r and 10 r gave the required results. In determining these exposure times the intensity of radiation directly within the cassette was measured with a thimble type chamber. The times required are shown in Table II.

After exposure, the films were developed in the thermostat tubes for five minutes at a temperature of  $18^{\circ} \pm 0.2^{\circ} \text{C}$ . (To observe the effect of temperature of development, one set of films was developed at  $17^{\circ}$  and another at  $19^{\circ}$ . Both sets gave results consistently different from those obtained at  $18^{\circ}$ .)

Before a film was placed in the developing tube, it was immersed in the water tray to change its temperature from that of the room to approximately the desired value. With the film in the tube, the developer was added and then stirred in a non-rhythmic fashion by the glass piston. This precaution was taken since positive agitation is necessary to produce uniform development, by keeping a temperature equilibrium, and by preventing a lowering of densities of film areas adjacent to high density regions. Rhythmic agitation of the developer may give rise to nodes of liquid motion in the tube and so produce banded regions of varying darkness along the film.

Despite the precautions used to obtain uniform development, the films were not uniformly darkened, possibly because of variations in the sensitivity or thickness of the emulsion.

It was found that the half-time strip, which should be of uniform density throughout, for the visual method of measurement outlined, varied in darkness along its length and introduced possibilities of error in measurement.

A comparison of densities of the half-time strip and those under the steps are shown in Table III.

In this case, the density of the half-time strip just opposite each step was taken down the whole length of the strip. The

photographic values would differ from those obtained by ionization. In other words, the values are modified by interposition of the photographic measuring method, which is essentially a transfer process, and which may introduce a variable factor of difference depending upon the responses of the film.

The higher values of the half value layer obtained photographically for aluminum in comparison with the ionization half value layer may possibly be attributed to secondary radiation from the metal steps. This radiation would increase the exposure under the steps, and consequently greater thicknesses of metal would be necessary to reduce the recorded density to that of the half value strip.

#### V SUMMARY

1 A comparison of photographic and ionization measurements of half value layers has been made for types of roentgen radiations usually employed in therapy.

2 To determine correct exposures for the films in the photographic method, Hurter and Driffield response curves were obtained.

3 The films were exposed and developed by a uniform process.

4 The photographic values of the half

value layers obtained were consistent with each other for a given condition of radiation.

5 The photographic values differed from those obtained by ionization methods by a variable factor, which permits no correction to be applied, and renders difficult the use of copper-aluminum photographic equivalents.

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For aluminum, the table shows the greatest and least values of the half value layer observed for any one condition to the right of the mean value. A least squares solution of probable error, for the

were obtained on a Kelley-Koett mechanically rectified system, operating at high kilovoltages, in an attempt to extend the curves to lower effective wave lengths)

While the aluminum half value layer

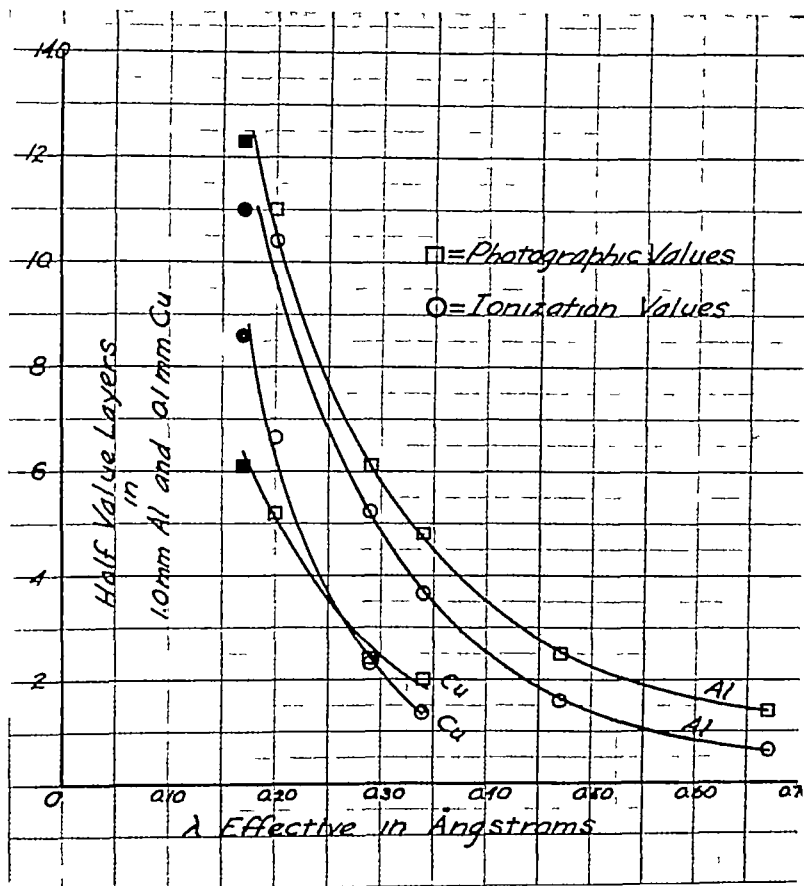


Fig 9 Half value layer curves in copper and aluminum obtained photographically and by ionization

fourteen sets of observations taken, is impossible, since the half value layers observed photographically differed from each other by an integral number of metal steps or thicknesses

The ionization half value layers shown are the averages of the two sets of absorption curves

For the curves of Figure 9 the effective wave lengths were determined to two significant figures by the Duane single filter method (The solid points on the curves

curves do not intersect, it is noted that with decreasing wave lengths the photographic copper half value layers are first less than, and then cross over to exceed the ionization values for the half value layer. Such a lack of parallelism would infer a relation between copper-aluminum intensity equivalents, taken photographically, that is different from the ionization copper-aluminum intensity equivalents. The effective wave lengths determined from the Duane equivalence curves, using

about physical condition, these were the specific factors noted here, together with any additional information relative to the

cal significance. It was the aim to make observations upon the subjects at the same time, on the same day of each week

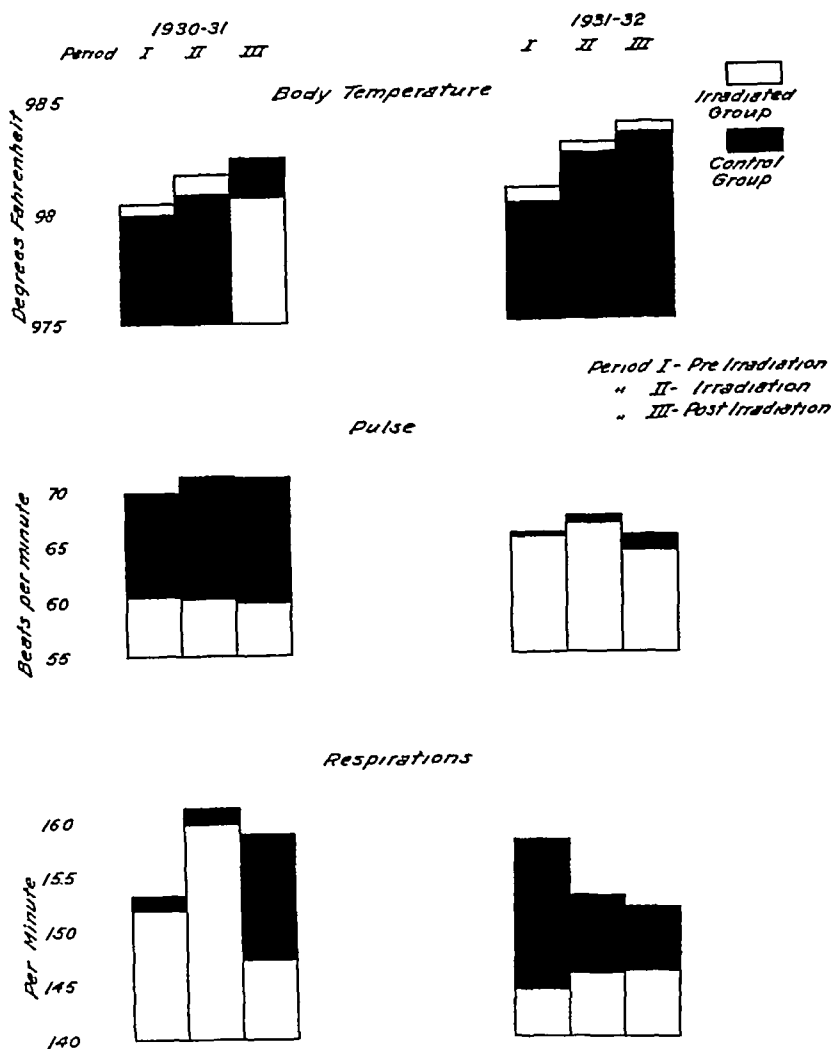


Fig 1 A diagrammatic representation of the average body temperature, pulse rate, and respirations for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930-1931 and 1931-1932

number of colds in either the irradiated or the control group, and the effect of radiation on sleep, appetite, and physical efficiency

#### EXPERIMENTAL WORK

It seemed advisable to keep the manipulations as simple as possible and at the same time an effort was made to choose methods which would yield results of clinical

significance. It was the aim to make observations upon the subjects at the same time, on the same day of each week during the entire course of the experiment. Thus, however, was not always possible and, when necessary, the time of appointment was changed to a free hour close to the original one. The study was planned to cover the dark portion of the year, *i e*, that time when such of the sun's rays as reach the earth contain the smallest amount of therapeutically effective near-ultra-violet radiation, which, for the lati-

# A STUDY OF SOME PHYSIOLOGICAL EFFECTS OF ULTRA-VIOLET IRRADIATIONS UPON NORMAL ADULTS<sup>1</sup>

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A SURVEY of the literature, published in the last few years, reveals little information describing the effect of ultra-violet radiation upon the physiologic blood picture of normal healthy adults. Many apparently do receive benefit from such treatments, but efforts to explain the results have not thus far produced a great unanimity of opinion regarding their influence on ordinary clinical data. There also seems to be urgent need for standardization of dosage, since methods of measuring and administering the radiations vary widely and the most evident effect, erythema, differs for different individuals, as cited by Coulter and Smith (1), Russell (2), Stenstrom and Gaida (3), Lane and Rockwood (4), Goodman (5), Waller (6), and Maughan and Dye (7). The type of lamp, subject (human or animal), and experimental conditions reported, must be responsible in part, at least, for the apparently differing effects of ultra-violet irradiation upon red blood cells, white cells, hemoglobin, blood pressure, pulse, temperature, appetite, and general metabolism, as cited by Russell (2), Mayer (8), Koenigsfeld (9), Eichelberger (10), Mason and Mason (11). Licknit (12), on the basis of work reported, has suggested that the beneficial effects of irradiation were psychic, generally with some local effect on the musculature in increasing the capacity for physical work, while Backmund (13) and Laurens (14) believe the effect to be from photo-electric or photochemical products produced. Johnston (15) feels that its tonic effect, while not a cure-all, may well be recommended along with other treatments as massage, diet, etc.

The effects of irradiation upon infections of the upper respiratory tract have been variously reported by Arbuckle (16), Maughan and Smiley (17), Doull, Hardy, Clark, and Herman (18), Bull, Maughan, and Waring (19). Edinow (20) finds that the effects of ultra-violet radiation on substances in the blood stream are not as marked as in other media. Contra-indicatory symptoms are pointed out by Troup (21). Mayer (8) believes that more information is necessary before irradiation may be prescribed by those unfamiliar with its use. The Council on Physical Therapy of the American Medical Association (22) suggests that the sunshine lamps, sold directly to the public, be so constructed that the radiant energy emitted shall approximate sunlight and that no curative claims shall be made by the producer. The Council is not convinced that human beings in health require the great amount of energy that many advertisements would advise, and believes that in every case a physician should first be consulted, before treatments are started.

In the present study, certain clinical data were noted from week to week, throughout the winter months of 1930-1931 and 1931-1932, with the object of observing the effect of ultra-violet radiation under normal conditions, the subjects being a group of college women at the University of Minnesota. Only one limitation was imposed, namely, that neither the control nor the irradiated group be allowed to take cod liver oil or other Vitamin D concentrate. By virtue of their occupations, it was felt that all subjects would receive slight but comparable amounts of direct sunlight during the experimental period. As, clinically, data are commonly recorded concerning the individual's weight, temperature, pulse, respirations, blood pressure, and blood counts, giving information

<sup>1</sup> Paper No. 1188 of the Journal Series of the University of Minnesota Agricultural Experiment Station. Data taken from the thesis submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirement for the Ph. D. degree.

was taken before, and other observations and treatments made after, a twenty-minute rest period, while the subject was still prone. Standardized pipettes, thermometers, and counting chambers were used, the blood samples being taken from

The source of ultra-violet radiation was a new air-cooled mercury vapor arc lamp, with a Cooper-Hewitt Uviarc burner. This lamp was used only for this study during the two-year period and was tested from time to time by the zinc sulphide

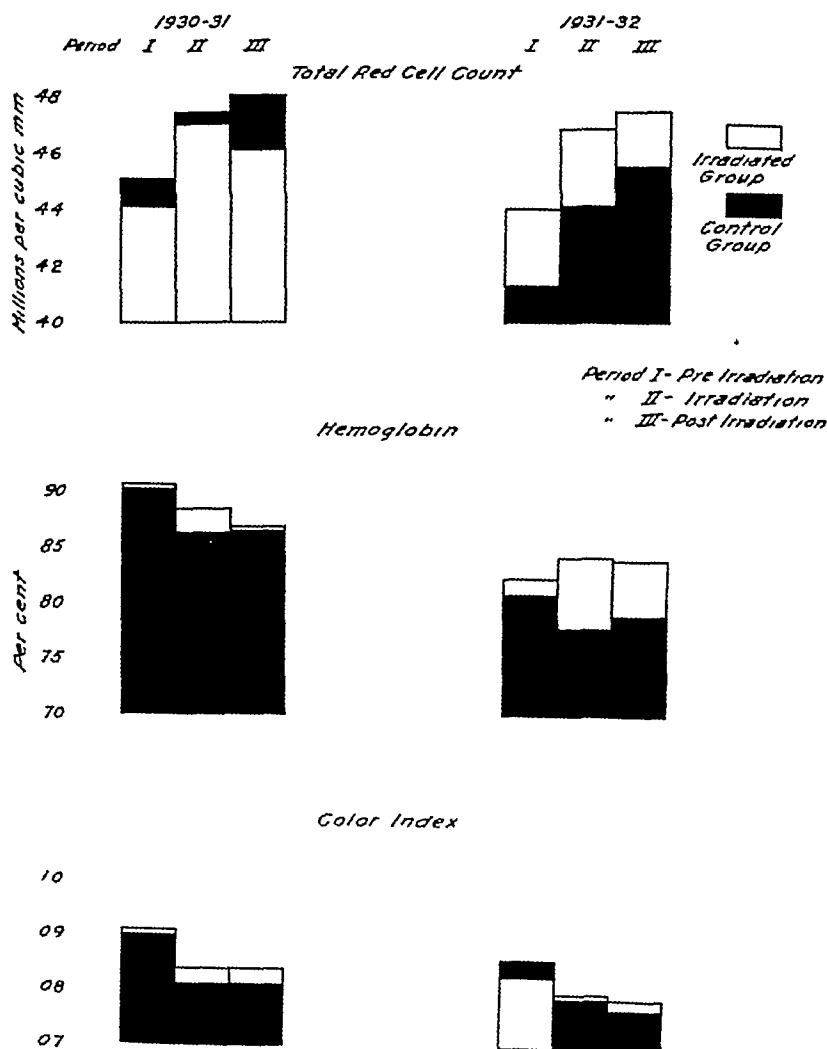


Fig 3 A diagrammatic representation of the average total red cell count, hemoglobin, and color index for the radiated and control groups during the three experimental periods the pre-radiation, radiation and post-radiation periods of 1930-1931 and 1931-1932

a spring lancet puncture in the ear lobes. Blood pressures were taken with a Becton-Dickenson portable mercury manometer, by the auscultatory method. Hemoglobin determinations were made by the use of the Sahli hemoglobinometer, with glass standards, and read with a daylight lamp

method of Janet Clark (23), to check the relative power of the lamp and its deterioration. No change was observed during the course of the experiment. The spectral emission curve, as reported by the manufacturer, indicated ultra-violet potency in the region of wave lengths 2,900-



tude of the experiment, is the period from November to March. The time covered by the experiment was divided into three parts for each year: a preliminary four-weeks' observation period, an experimental

Ultra-violet treatments were not interrupted during the menstrual period, the onset of menstruation being recorded in each case.

The age range of the groups was from 21 to 38 years. The personnel of the groups was

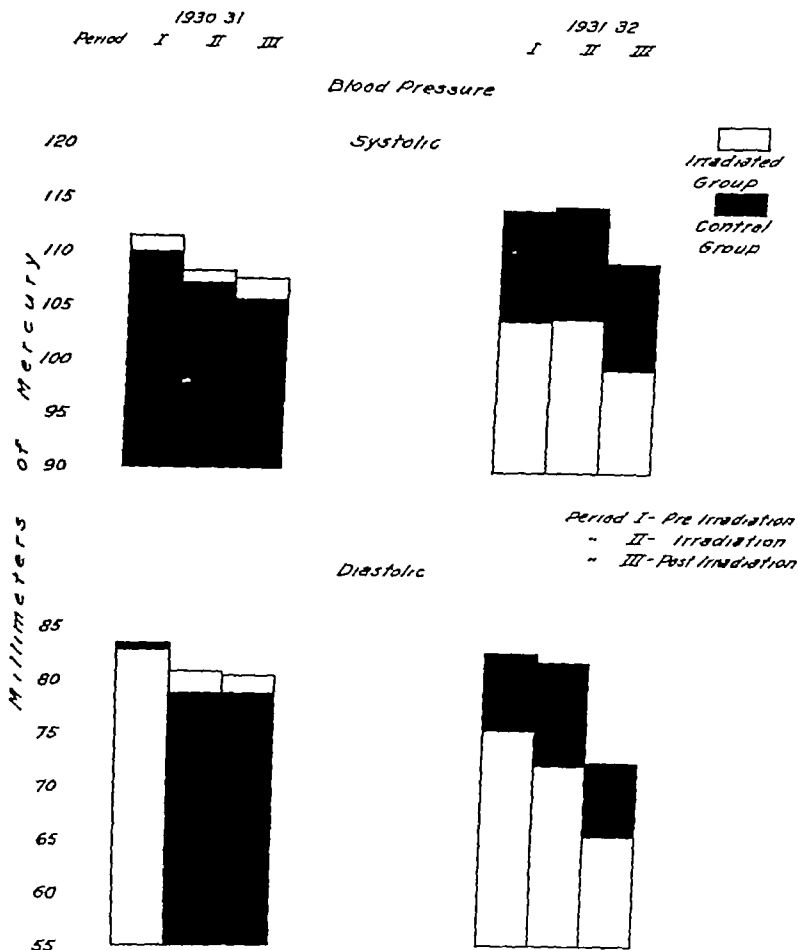


Fig 2 A diagrammatic representation of the average systolic and diastolic blood pressures for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930-1931 and 1931-1932

period of several months, during which one-half the group (six subjects) received ultra-violet radiation, and a final observation period similar in length to the first, without radiation. The above-mentioned data were checked weekly, including total red and white and differential white counts and, in addition, the apparent effect of radiation upon the skin and the number of colds

chosen on the basis of histories taken. Appointments were arranged during morning and afternoon hours, never less than two hours after a meal, to avoid effects of digestion or excessive fatigue.<sup>2</sup> The weight

<sup>2</sup>Since the preparation of this paper the following study has been reported: Lawrence J S, Stephens D J, and Jones E. Effect of Digestion on White Blood Cells. Am Jour Physiol 1933 CVI, 309-313

TABLE II—WEATHER REPORT

(U S Department of Agriculture, Weather Bureau, Minneapolis, Minn)

1930-1931	Monthly mean temp , ° F	Highest temp , ° F	Lowest temp , ° F	Sunshine percentage possible	Days, clear	Days, partly clear	Days, cloudy
October	48	86	21	51	7	9	15
November	37	68	- 4	59	9	6	15
December	23	45	-11	38	7	5	19
January	26	52	- 5	47	5	11	15
February	32	57	0	60	12	4	12
March	31	51	12	51	6	6	19
Average				51			
Totals					46	41	95
1931-1932							
October	54	81	38	53	13	4	14
November	40	68	12	39	7	8	15
December	30	48	- 1	35	7	6	18
January	18	42	-17	32	4	7	20
February	19	57	- 7	52	6	10	13
March	22	62	- 6	52	4	10	17
Average				43.8			
Totals					41	45	97

study of the pulse changes (Fig 1) shows the behavior of the two control groups and the radiated group, 1931-1932, to be similar, with a difference between initial and final averages not greater than 1.5 beats per minute. These findings agree with those of Eichelberger (10), Paschetta (25), and Fries and Topper (26). The respiratory rate, too, seemed unaffected, since the difference between group averages from period to period was less than one per minute. It would seem probable that blood pressure variations (Fig 2) were caused by such factors as fatigue and mental stress rather than radiation, as the control and irradiated groups behaved similarly. A difference in blood pressure at different times during the day was reported by Greisheimer, Merrill, and Lynch (27). It will be noted (Figs 3 and 4) that the increases in the red cell count of the irradiated group (1931-1932), receiving nearly three times the total radiation of the group in 1930-1931, was similar to that of the two control groups. Thus it is apparent that, under these experimental conditions, ultra-violet radiations had little influence on the total red cell count. According to Spence (28), Furniss (29),

and Russell (2) a different response is obtained in pathologic cases, in which the tendency under ultra-violet stimulation is to increase the red cell count toward the normal average figure.

The hemoglobin of the control groups (Figs 3 and 4) behaved similarly and the general trend was much like that of the first year's radiated group. The radiated group the second year had a definitely higher average in the Spring than at the beginning of the observations in the preceding Fall. The increase was not gradual and maintained, but showed several peaks. The maximum ultra-violet dosage, reached and maintained from about the eighteenth or twentieth week to the twenty-second, did not keep the hemoglobin percentage above 85. The marked drop in hemoglobin, during the Christmas holiday and that in the later weeks of radiation (1931-1932), might result from a previous apparent rather than a real increase, due to the temporary mobilization of hemoglobin reserves from different parts of the body. The hemoglobin increases in the post-radiation periods may in some unidentified way be associated with seasonal factors or slight changes in general group activities.

TABLE I — RADIATION ADMINISTERED  
1930-1931

1930-1931		1931-1932	
Subject	Amount received	Subject	Amount received
A	2 hrs 29 min	A	7 hrs 4 min
B	2 hrs 17 min	C	4 hrs 2 min
C	2 hrs 17 min	D	7 hrs 34 min
D	2 hrs 35 min	L	2 hrs 42 min
E	2 hrs 15 min	M	7 hrs 21 min
F	2 hrs 17 min	N	7 hrs 34 min
Total	14 hrs 10 min		36 hrs 17 min

3,150 Ångstrom units The lamp was operated at 75 volts and 30 inches from the subject, the ventral and dorsal surfaces being exposed, with the burner directly over the trunk The treatments were given as follows

During the years 1930 and 1931 the subjects were irradiated once a week, the initial dose being one-half minute, the second, one minute, and each succeeding dose increased by one minute until a maximum of ten minutes, front and back, was reached Two ten-minute treatments were given

As the total amount of irradiation was relatively small the first year, the plan of dosage administered was somewhat altered and augmented during the second (Table I)

During the years 1931 and 1932, the subjects were irradiated twice a week, the initial dose being one-half minute, and each dose following increased by one-half minute, front and back, to ten minutes The semi-weekly ten-minute irradiations were continued from three to four weeks, provided no discomfort was felt

#### DISCUSSION

It will be seen that weather conditions during the two seasons were very similar (Table II) It is doubtful whether the slight difference in available sunshine materially influences the results, when one considers the winter clothing required and the occupation of the subjects Since the tolerance of the different subjects was found to vary markedly the original schedule had to be varied somewhat to continue the suberythema dosage for each person, as cited by Buttolph (24) (Table I) The

controls who wished it were given ultra violet treatments at the end of the experiment each year, and in some cases subjects who belonged to the control group the first year became members of the radiated group the second

Certain unexplained responses were noted Subject L, not sensitive at the end of the first year to a moderate amount of ultra-violet radiation, seemed hypersensitive to the second, four months after an operation for the removal of an infected gall bladder Subject T, a control the second year, three months after an emergency appendectomy, showed no sensitivity to radiation Subject C felt no discomfort the first year, nor the second until after an attack of influenza, when she was decidedly sensitive for several weeks At the end of the second series of treatments, this same subject had an apparent decrease in the clotting time of the samples for blood counts She reported that her menstrual flow was more scanty and clotted than normal The tendency of the menses to clot decreased after radiation was discontinued No method was employed to measure pigmentation, but a moderate degree seemed to have been developed by the different members of the groups, as a result of the radiation

Marked variations were evident in the individual data collected from week to week It seemed advisable, therefore, to consider group behavior as a whole (Figs 1, 2, 3, 4, 5, 6) The widest fluctuations in individual temperatures apparently occurred as a result of factors other than the radiation, as colds and influenza, the group averages showing no consistent effect attributable to the treatment given A

In accordance with the work of Garrey and Butler (30), Ashmarin and Alekso-Berkman (31), and Smith and McDowell (32), it would seem that irregularities observed in the total white cell counts were due to factors other than ultra-violet radiations, such as lack of physical or mental

ing the administration of ultra-violet rays, the second year. The fluctuations of all four groups are fairly wide (Fig 6), which makes the definite interpretation of any one variation rather difficult. The number of colds among the members of both control groups was the same, though the

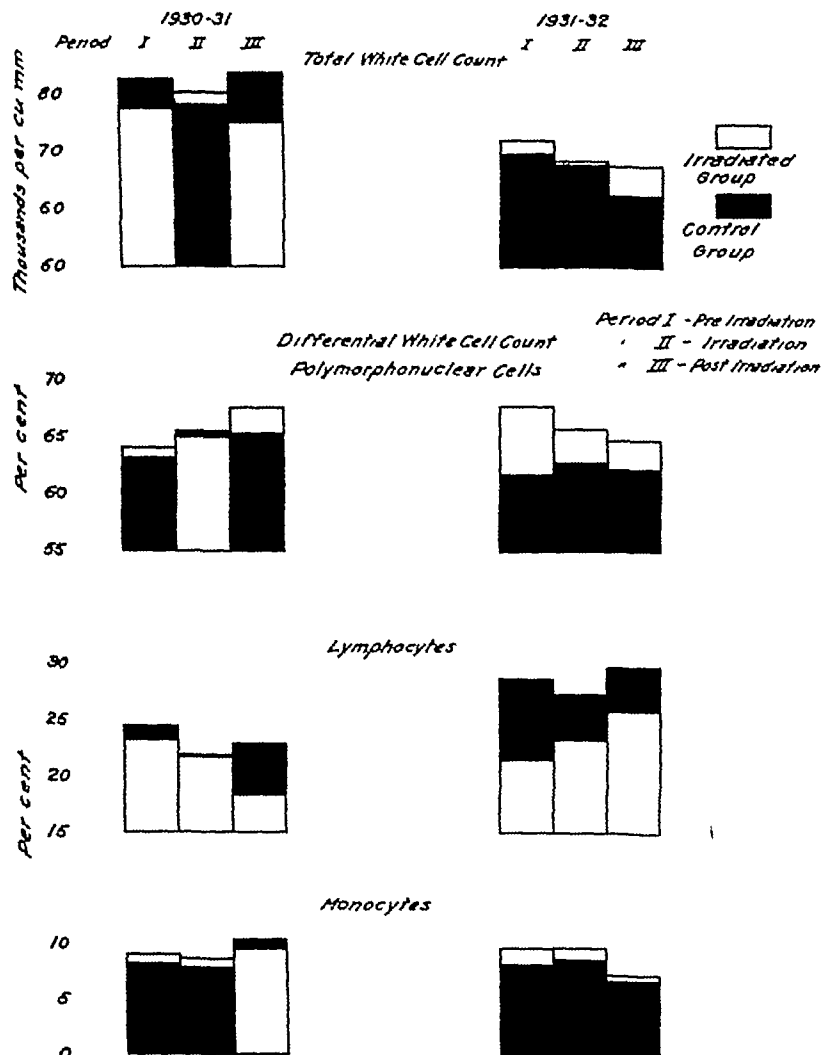


Fig 5 A diagrammatic representation of the average total white cell and differential white cell counts for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930-1931 and 1931-1932

relaxation and infections (Fig 5). The average differential counts for the control groups were similar both years, while the response of the radiated groups was reversed (Fig 5), an increase in lymphocytes and a decrease in the percentage of polymorphonuclear cells having occurred dur-

personnel differed (Table III). A decrease in total number of colds and estimated days of infection will be noted in the radiated group the second year. A greater number of cases of influenza occurred in 1931-1932, which would suggest that if ultra-violet rays, as administered,

Possibly also, for the purposes of stimulating hemoglobin formation, several short radiation periods, with breaks between them, are more effective than a continued treatment. Accepting 4,500,000 red cells per cubic millimeter as the normal for women, color indices fluctuated, but showed a gen-

eral decline from Fall to Spring, followed by an increase. As Spence (28) found that the red cell count usually increased faster than the hemoglobin, it is possible to have a decreasing color index (Period 3, 1931-1932), while both red cells and hemoglobin are increasing.

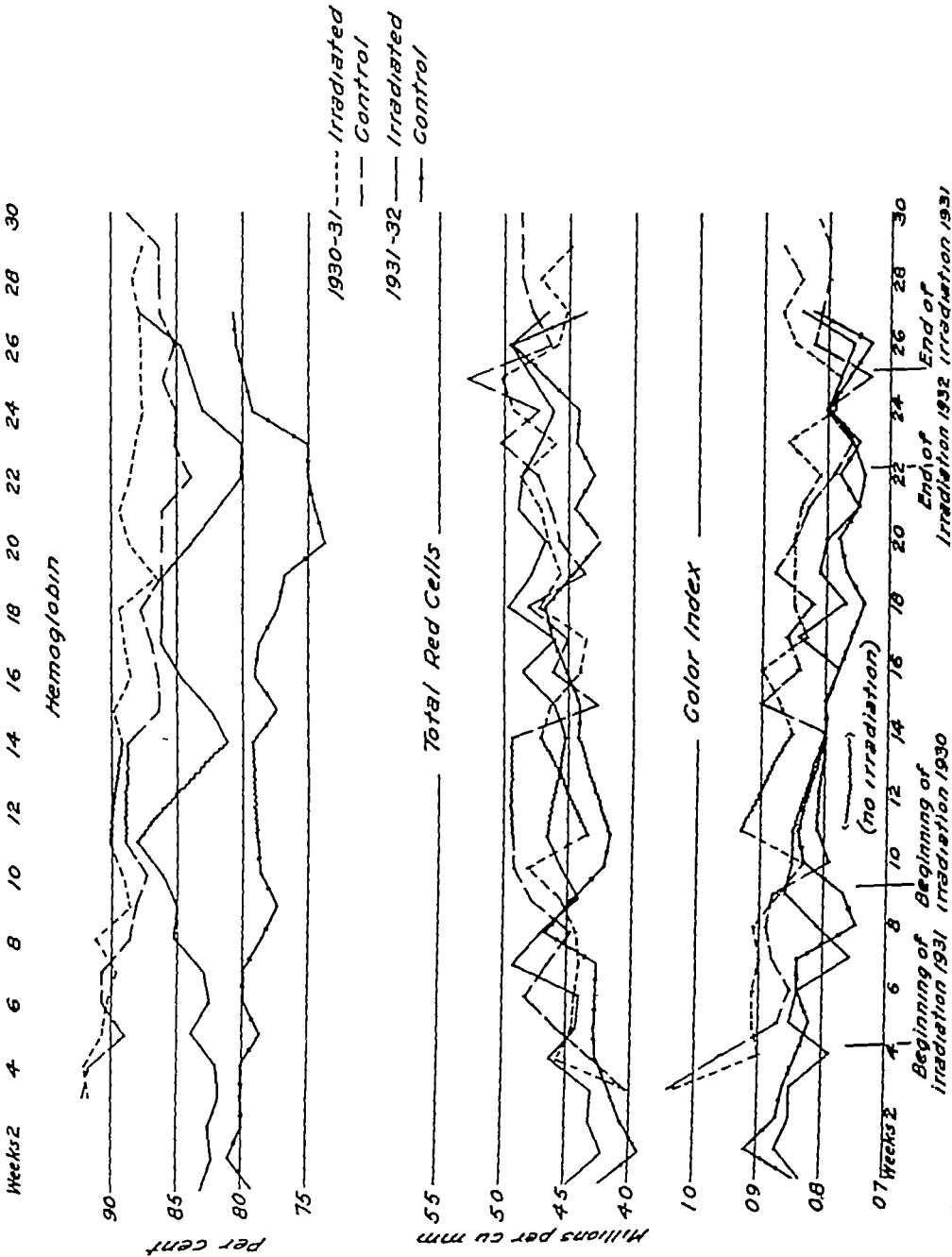


Fig. 4. A graphic representation of the weekly average hemoglobin, total red cell count and color index for both irradiated and control groups throughout the experiment in 1930-1931 and in 1931-1932.

In accordance with the work of Garrey and Butler (30), Ashmarin and Alekseo-Berkman (31), and Smith and McDowell (32), it would seem that irregularities observed in the total white cell counts were due to factors other than ultra-violet radiations, such as lack of physical or mental

ing the administration of ultra-violet rays, the second year. The fluctuations of all four groups are fairly wide (Fig 6), which makes the definite interpretation of any one variation rather difficult. The number of colds among the members of both control groups was the same, though the

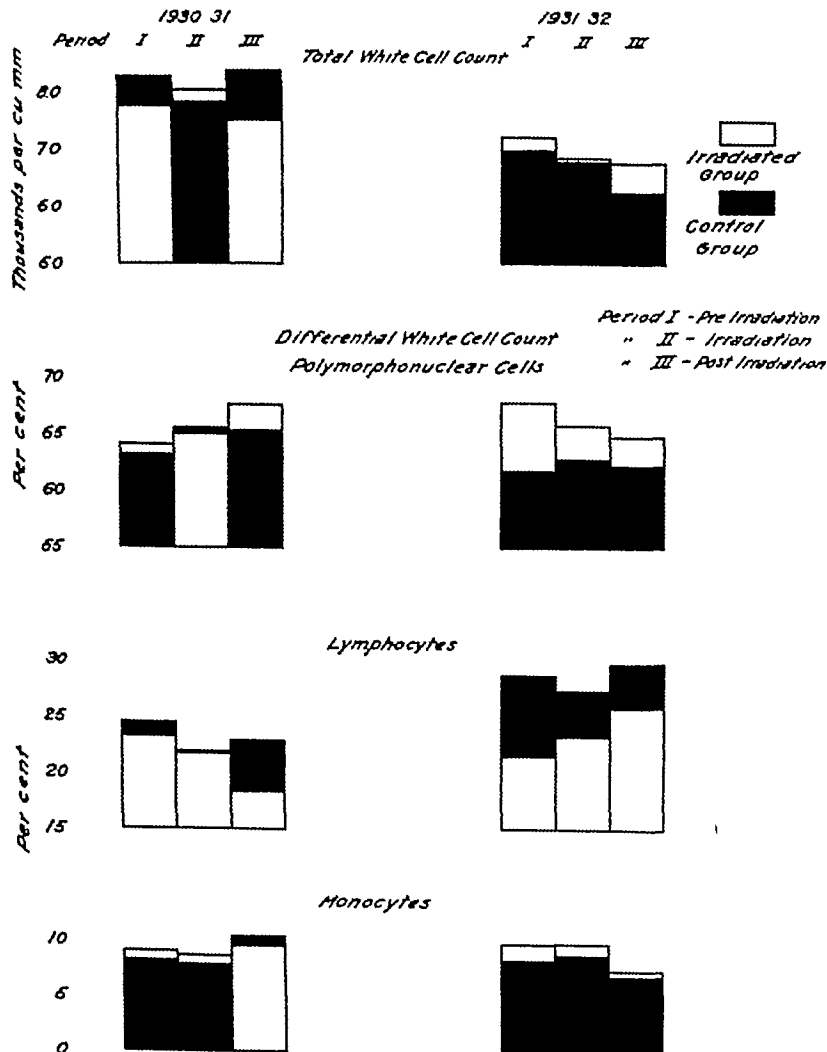


Fig 5 A diagrammatic representation of the average total white cell and differential white cell counts for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post radiation periods of 1930-1931 and 1931-1932

relaxation and infections (Fig 5). The average differential counts for the control groups were similar both years, while the response of the radiated groups was reversed (Fig 5), an increase in lymphocytes and a decrease in the percentage of polymorphonuclear cells having occurred dur-

personnel differed (Table III). A decrease in total number of colds and estimated days of infection will be noted in the radiated group the second year. A greater number of cases of influenza occurred in 1931-1932, which would suggest that if ultra-violet rays, as administered,

did have some beneficial effect in cold-prevention, the dosage was not effective in conferring immunity from influenza

From any subjective observations within the scope of this study neither appetite nor sleep of the subjects was specially bene-

fited, though two subjects reported that they "felt better" and their efficiency seemed to be improved during this period

In health, the human body has amazing powers of compensation, so that mild shocks of varying types may have little or

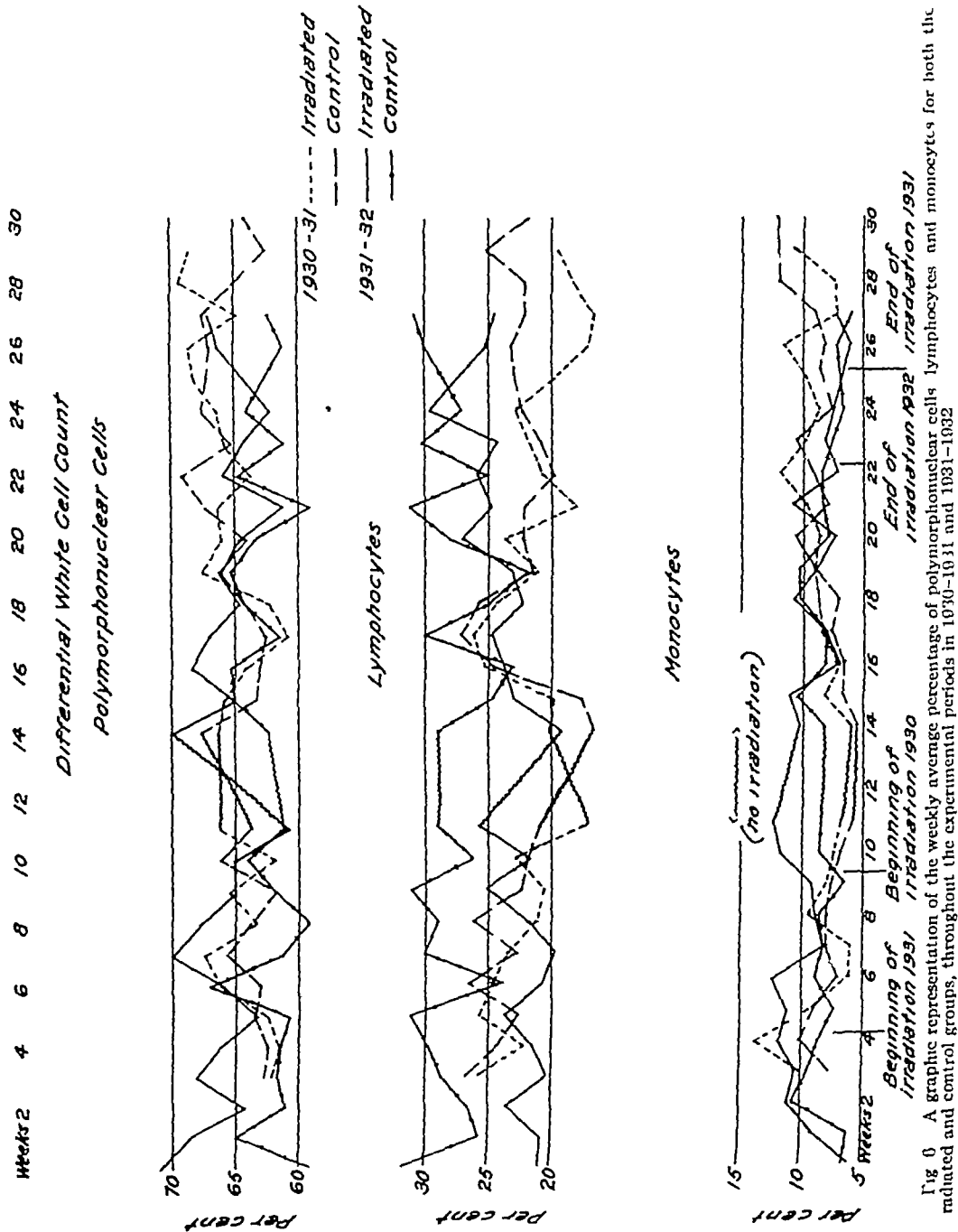


Fig 0 A graphic representation of the weekly average percentage of polymorphonuclear cells, lymphocytes and monocytes for both the irradiated and control groups, throughout the experimental periods in 1930-1931 and 1931-1932

TABLE III — COLDS AND OTHER INFECTIONS

Subject	Number of colds	Days infected	Other infections
Irradiated Group, 1930-1931			
A	3	13	None
B	3	12	Subject to chronic sinus infection
C	2	10	None
D	5	16	None
E	3	25	None
F	5	21	Subject to chronic sinus infection
Totals	21	97	
Control Group, 1930-1931			
G	3	17	None
H	1	3	None
I	3	18	Influenza, 4 days
J	3	17	None
K	3	16	None
L	1	8	Quinsy, 4 days
Totals	14	79	Influenza and quinsy, 8 days
Irradiated Group, 1931-1932			
A	1	4	Influenza, 5 days
C	0	0	Influenza, 21 days
D	1	4	None
L	1	2	Quinsy, 1 week, influenza, 3 weeks
M	4	16	None
N	1	5	None
Totals	8	31	Quinsy (7), influenza (47), 54 days
Control Group, 1931-1932			
O	2	9	Influenza, 4 days
P	1	3	None
Q	3	21	Influenza, 3 days (subject to sinus infection)
R	4	18	None (chronic sinus infection)
S	4	11	Two light attacks of influenza, 6 days
T	0	0	None
Totals	14	62	Influenza, 13 days

no evident effect on the various body processes, and the apparent benefit resulting in many cases from ultra-violet treatments may certainly be psychologic rather than physiologic. Much remains to be explained regarding the salutary effects of such exposures for the average person, and conditions for and responses to treatments require further study before such treatments may be given indiscriminately. Future explanations of the results may be based on the further study of blood chemistry in the light of the behavior of such glands of internal secretion as the parathyroids.

## SUMMARY

1 During the winter months of the years 1930-1931 and 1931-1932, two groups of healthy women were subjects

for a study of the effect of ultra-violet radiation upon certain factors of clinical significance, such as temperature, pulse, respirations, blood counts, and blood pressure. The use of cod liver oil or other Vitamin D preparations was forbidden all subjects. One-half the group each year (six subjects) received ultra-violet radiation after the various weekly observations were made and blood samples taken. The control groups received no radiation during the experimental periods. During the second year (1931-1932) treatments were given twice, instead of once, a week and the subjects received approximately three times the amount of ultra-violet radiation as that given a similar group the preceding year.

2 Hemoglobin production appeared more pronouncedly affected the second



year than the first, though the effect did not continue indefinitely. It has not been determined whether this hemoglobin increase was real or apparent, due to the temporary mobilization of the hemoglobin reserves of the body.

3 The slight increase in the average total red cell count cannot be attributed to the effect of ultra-violet rays, as the control group behaved similarly.

4 The color indices of all groups decreased in a comparable manner from Fall to Spring.

5 Body temperature, pulse rate, and respirations appeared to fluctuate irrespective of ultra-violet irradiations.

6 Throughout the first experimental periods the average systolic and diastolic pressures of the control group showed a slightly greater decrease than that of the irradiated group. The second year the decreases were almost identical.

7 The total white counts appeared to be influenced less by ultra-violet rays than by other factors. During the first year the average percentage of polymorphonuclear cells of the radiated group increased and the lymphocytes decreased. The reverse was true during the second year.

8 With the greater amount of irradiation (1931-1932), the number of colds appeared to have been favorably influenced.

9 Irradiation, as here administered, produced no manifest effect upon appetite, weight, sleep, or physical efficiency of the group as a whole.

10 In general, ultra-violet radiation did not seem to influence type or regularity of menstrual flow. In one case only did there seem to be a decrease in blood-clotting time and in the amount of the menses.

11 The normal individual seems to have powers of compensation sufficiently great to counteract any stimulation resulting from ultra-violet radiation as administered in this study. Hence, in the various factors considered, the more nearly the person approached the physiologic norm, the less evident the effects from moderate ultra-violet treatments.

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## X-RAY AND CATHODE RAY TUBES IN THE SERVICE OF BIOLOGY<sup>1</sup>

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SINCE the development of the hot cathode x-ray and the high voltage cathode ray tube such manifold and far-reaching uses for x-rays and cathode rays in the service of humanity have been uncovered that the mere mention of most of them simply constitutes a repetition of what has already become universally well known. To introduce the use of the x-ray in general and dental surgery, in cancer research, or in its thousand and one industrial applications, is excusable only on the basis of extended knowledge and experience in each field and the presentation of original detail.

There is one application of x-rays and cathode rays, however, of which we should like to say a few words. It is rather new, and, on the whole, not particularly well-known in general. Its future possibilities may be great, and, whether they be great or small, they must concern us as individuals in an unusually vital way. We refer to the alteration of hereditary traits and the creation of new varieties in plants and animals through the alteration and deformation of cell chromatin under x-ray and cathode-ray bombardment.

It is curious that, although adequate realization of the potentialities of x-rays and cathode rays in the alteration of cell chromatin and the production of heritable variations has been quite recent, and all of the best work dates from later years, the first experimental work in the field was undertaken at an early date—early on the scale to which most of our present-day creative work is set. As early as 1899 Lopprioni, using a cold cathode x-ray tube, worked with *Vallisneria*, *Gemsta*, and *Darlingtonia*. His results, though positive,

interpretation or by actual deficiency not be told. Perthes, in 1904, worked with the ova of the worm *Ascaris*, demonstrated a marked retardation of cell division in irradiated material, and in the same year Gilman and Baetjer produced acceleration of embryologic development, deformation of embryos, and abnormal larvæ by the irradiation of ova of the mander *Ambystoma*. The same work later produced abnormal young chicks from x-rayed hens' eggs.

Attempts to apply results such as these followed very quickly, but they were clearly premature, and for the most part were not fruitful. Bordier, working with silkworms, produced only destructive results, as did Hasebroeck with rabbit larvæ, though Hastings, Beckton, Wedd claimed an acceleration of embryologic development. Some work also done during this period on the problem of the effect of x-rays upon leukocyte production in the blood, upon which much excellent work has been done in recent years. Benjamin, Reuss, Slesinger, and Schwartz, Aubertin and Beaujeu, and Murphy and Norton all claimed stimulation—a verdict which might be simply interpreted to-day.

The first especially notable morphological work on the effect of the x-raying of seeds upon the subsequent growth of the seedlings was probably that done on sunflowers, tomatoes, and cosmos by Dr. L. Johnson, in 1926. Applying the E-unit of dosage (representing the radiation received by an object at 30 cm focal distance, with a 5 cm portal of entry from a hot cathode tube operated at 60 K V and 6 ma, with no filter), Johnson found a marked difference in the effect on wet

mutational effects. Some extraordinary aberrations appeared in seedlings from x-rayed seeds—ribbon-shaped stems, increased branching, dwarfing, doubled leaves and flowers, a shorter period from planting to flowering, and an initial decrease, followed by a marked increase, in the growth rate were all among the results secured.

Gager and Blakeslee, in 1927, reported similar experiments with *Datura*. Seeds exposed to radium beta radiation gave rise to a number of mutant types, characterized by differing form of flowers and leaves. Johnson continued her work on sunflowers in 1928, with results confirmatory of the earlier reports.

Early in the same year, Goodspeed and Olsen reported the beginning of a series of remarkable researches on the effect of x-rays on the growth and quality of the tobacco plant, using a hot cathode tube with air-cooled tungsten target, operated at 50 K V P and 2.8 milliamperes. Over one thousand plants were grown with seed fertilized with x-rayed pollen, and of these 20 per cent on the average represented new variants. In one batch, 136 out of 168 plants were of new types. Dwarf, low, and tall varieties appeared, varieties with large leaves or small leaves, dark bottle-green leaves or light gray-green leaves, tough leaves or tender leaves, light pink, pink, or purple-red flowers. The wealth of cytologic material which these variants presented was such as to make a complete investigation of it extremely difficult.

Concurrently with Goodspeed and Olsen, L. J. Stadler reported effects of x-rays on maize and barley, resulting in the production of mosaic corn, and white, vine-shaped, variegated and other striking types of barley—results which have initiated much excellent work since. McKay and Goodspeed similarly conducted work on cotton, producing many conspicuous variants. One of the most interesting of these bore bolls in which the seed was free of the lint, while in another, giant seeds were produced. An extension of the cotton work was made public in June, 1931,

by Horlacher and Killough, who produced a variety of creeping stock, changes in the shape of the leaves, remarkable color varieties, and other abnormalities.

Most of these workers, and many others of whom lack of time forbids mention, conducted a certain amount of cytologic work on x-rayed material, and found extraordinarily interesting chromosome abnormalities resulting from the treatment, even in stock appearing morphologically unchanged. J. W. Mavor was the first to discover the fact that chromosomal abnormalities of a very striking character appear consistently in a high percentage of x-rayed organisms. Using *Drosophila* as his material, he succeeded in demonstrating deletion, non-disjunction, and attachments of various kinds in germinal cells, in which entire fragments of chromosomes might be broken and destroyed or attached elsewhere, and the elimination of an entire sex-chromosome. H. J. Muller, in Texas, in 1927, first demonstrated actual single-locus mutations in x-rayed stock of *Drosophila*, and his work has since become classic. The rate of mutation among progeny of irradiated flies in some of Muller's experiments was 15,000 per cent greater than among the controls. Other workers in the same field have become too numerous to name individually, but their results are nearly all in substantial agreement with those of Mavor and Muller in indicating the extraordinary fertility with which mutations are produced in x-rayed material. Anderson, Babcock and Collins, Barth, Congdon, Demerec and Farrow, Dobzhansky, Hanson and Heys, Hanson and Winkelman, Harris, Hussey, Painter, Patterson, Serebrovsky, and Timofeef-Ressovsky, to mention only a few, have all reported extraordinarily interesting findings with the fruit fly.

Other workers have applied similar methods to cytological work in other organisms, including some at present of economic importance. Whiting's work with induced mutations in the wasp *Habrobracon*, Little and Bagg's with mice, and Curtis' with *Planaria* are too generally

well known to require elucidation, but they are extremely significant in indicating the extent of the possibilities to-day in carefully controlled biophysical genetics

It was with such a background as we have roughly, briefly, and incompletely sketched that, a year ago, our Laboratory became interested in this field and has attempted to contribute to it. We are going to outline briefly the types of problems upon which we have been engaged, to mention such few results as we have yet achieved, and to indicate, above all, what our hope for future work is, and what is our concept of the sort of help that a physical laboratory can be in dealing with biologic problems of this character

Our ignorance at the beginning of our work compelled us to make it entirely morphologic in nature, and further forced us to do a great deal which was of a purely elementary character in the determination of tolerances for different materials, which were found to vary widely. Bulbs, seeds, pollen, and buds of a wide range of plant material were x-rayed, cultivated, and carefully watched for evidences of mutational changes. In order that this work, crude though it was, should yet constitute some contribution to knowledge, we worked largely with 200 K V tungsten radiation, since the bulk of work has been done at lower voltages. Chromosome constitution was little considered in this early work, while economic importance was a controlling factor. A considerable number of mutational results of some interest were secured in citrus fruits, narcissi, gladioli, and the lilies, and a number of crop plants. Cytologic analyses of the most interesting of these will be made during the coming winter.

We next worked from a more purely genetic standpoint with genetically controlled material. We became interested in following the course of a heterozygote containing one or more recessive factors in rather large x-rayed populations. Thus in crossing two of Ferguson's petunia stocks, kindly given us by Dr Dale, of Union College, one containing a recessive for

"stippling," the other for "variegation"—conditions represented respectively by numbers of colorless individual cells in the petal tissue and by large groups of colorless, air-filled cells—the first generation should normally be non-stippled, non-variegated, since both characters are recessive and they are non-allomorphic. In large populations of x-rayed seed, however, a certain percentage of the seedlings were found to exhibit the character "variegated" although this effect did not once appear in more than 500 controls—a result presumably due to x-ray inactivation of the dominant, allelomorphous, normal chromosome locus. A similar experiment is being carried forward with large populations of a type of sorghum heterozygous for albinism, kindly presented us by Dr R. E. Karper, of Texas, who first discovered the condition as a head mutation.

In another interesting experimental program now in course of development, we have found it possible to produce, in a petunia stock of known chromosome constitution, a definite somatic color mutation with a definite quantity of x-ray energy. The mutation is reproducible, as we have proved on several occasions that it proceeds through a definite cycle in succeeding flowers of the affected plant, but can be kept constant by re-irradiation at proper intervals. There is some indication that it is specific, within wide limits, for energy inputs. Whether or not it may be germinal, we do not at present know.

We have entered the field of x-ray animal genetics in controlled material with the little killifish *Lebistes reticulatus*, in an investigation of x-ray induced changes in the male sex chromosome. The guppy, we believe, will prove peculiarly suitable for this work, since the careful researches of Ojvind Winge, at Copenhagen, have indicated very definitely that in *Lebistes* the Y-chromosome is well filled with determinants of color in the male and, therefore, presents opportunities for analysis unobtainable with *Drosophila*.

Cytologic investigations are in progress at the moment in connection with the

Laboratory concerning changes brought about in the spiral chromonema within the chromosome in pollen mother cells of *Tradescantia* exposed to various wave lengths of x-rays and to cathode-ray bombardment

On the more analytical side, we have become extremely interested in the inhibitive effects of x-rays and cathode rays on growth in single cells, the material used at the moment being pollen grains of the *Lilacæ* and spores of the mold *Penicillium*. The output of a cathode-ray tube has been measured in roentgens, and a comparative study of the relative effect on the survival ratio of equivalent energy inputs of x-rays and cathode rays is in progress, leading to the interesting provisional conclusion that different energy inputs may be required to produce equivalent survival ratios in the same material. Confirmation of such a result and its explanation remains for the future.

We plan to undertake some investigative work in a number of related fields which seem of interest and promise, and in which we hope that we can be of some service as contributors, as soon as time and facilities are available. Such fields, of course, abound, and careful selection, as everywhere, is necessary here. Data are badly needed in the field of the genetic effect of secondary x-radiation set up within the tissues as in secondary x-ray cancer therapy. We hope to undertake

work in the field rather soon, using perfused *Drosophila* larvæ as material. Studies of the alteration of the sex ratio at the point of lethal limit of viability for one gamete are very desirable, especially with dioecious plants, in which they may well contribute to knowledge of the now little understood mechanism of sex determination in such organisms. Work has been begun in this field, using the strictly dioecious hemp as material. Studies in radiation effects in the so-called bacteria-bacteriophage "conjugations" seem extremely desirable, and work of this character has been begun in Schenectady by one who, though not in the Laboratory, enjoys its facilities.

It is our hope and belief that, in the future, we may make some real contribution to progress in the field of radiation genetics and kindred effects. We believe that we stand in a position, by reason of the unusual physical facilities in x-ray and cathode-ray tubes and the unusual wealth of physical information at our command, to perform a real service to biophysical science, to some extent in prosecuting biophysical work ourselves which will be carried through to the best of our ability, and to a greater extent in the initiation of and the assistance in work elsewhere in this, clearly one of the most significant of the frontiers of modern scientific investigation.

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# PNEUMOPERICARDIUM FOLLOWING A FOREIGN BODY IN THE ESOPHAGUS<sup>1</sup>

By ROBERT A. ARENS, M.D., and ELLEN STEWART, M.D., *Chicago, Illinois*

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**P**NEUMOPERICARDIUM was first described by Bricheteau in 1844, and his diagnosis was confirmed by the autopsy findings. James (1903) reviewed 38 cases of pneumopericardium, while Gottesman and Bendick (1926) added seven more. The writers have been able to find four other cases in the literature, those of Arrernes (1926), Leys (1926), Molnar (1927), and Imperatori (1928), which make a total of 49 cases. A few of the foregoing cases are the result of spontaneous gas production from infected

pericardial fluid, but the majority of them are the result of traumatic perforation of the pericardium from within or from without, of perforation into the pericardium from a neighboring organ, or the perforation of a diseased pericardium into a neighboring organ.

Pneumopericardium in man, resulting from a perforation of the esophagus due to a foreign body, however, is found less frequently than either pneumopericardium due to penetration of a foreign body through the chest wall, or to a contusion of the thorax. Pneumopericardium in animals, resulting from perforation of the esophagus by a foreign body, is a frequent

<sup>1</sup> Read before the Section on Radiology, Illinois State Medical Society, Springfield, May 18, 1932.



Fig 1-A Anteroposterior projection showing pneumopericardium with open safety pin *in situ*. Note the thickness of the pericardial sac.



Fig 1-B Lateral projection of same case shown in Fig 1-A.

finding Imperatori mentions that numerous cases are found in monkeys, induced by biting off and swallowing pieces of barbed wire from their inclosures Brailsford (1929) also states that it is commonly found in cattle sent to the public abattoir, due to swallowing long strips of sharp metal or wire

Only four cases of pneumopericardium resulting from foreign bodies in the esophagus have been noted in the literature by the writers All of these ended fatally Buist (1839) reported a case of pneumopericardium in an adult, the result of swallowing a dental plate This condition, however, was not recognized during life, but was found at autopsy fourteen days later Walsh (1873) reported pneumopericardium from an esophageal wound due to swallowing a sword, which was diagnosed during life, while James (1904) cited a case of pneumopericardium in a girl 25 years of age, resulting from a shiver of bone perforating the esophagus This was diagnosed during life, and at autopsy ten days later two oval openings were found in the esophagus, each 2 cm in length, directly opposite each other, one of which perforated the pericardium In 1928, Imperatori reported a case similar to ours, in an infant 13 months of age, who swallowed an open safety pin An autopsy revealed a pericardial-esophageal fistula

*Clinical History*—W M, eight-months-old infant, entered the Sarah Morris Hospital, service of Dr Jesse R Gerstley, May 22, 1928 A cough which had developed five days previous to entrance, was the chief complaint made by the mother at the time of admission

The following history was also obtained The child had been well until, five months before hospitalization, when there was bleeding from the bowel for a day, followed by tarry stools The passage of bright red blood was seen one month later, this as before being followed by the passage of tarry stools At this time the mother had found the baby "blue, stiff, and seemingly dead" for several minutes Since then



Fig 2 Right oblique projection showing pneumopericardium with barium-filled esophagus and open safety pin at about the level of the esophageal hiatus Note the barium at point of pin and free communication into the pericardium

there had been difficulty in swallowing, an anorexia, and a loss of weight

Physical examination on admission showed an undernourished white child of eight months, with moderate beading of the costochondral articulations There was some impairment of resonance in the left base posteriorly, with the lung fields elsewhere negative The abdomen was flabby and distended The liver was firm, extending 4 cm below the right costal margin The tentative diagnosis was a rachitis of moderate degree, a mild pharyngitis, and a resolving left lobar pneumonia

A roentgenogram, taken because of the probable pneumonia, revealed a pneumopericardium, with an open safety pin lying in the esophagus between the seventh and tenth ribs posteriorly The open end was up and the closed end was at the cardia of the stomach (Figs 1-A and 1-B)



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**P**NEUMOPERICARDIUM was first described by Bricheteau in 1844, and his diagnosis was confirmed by the autopsy findings. James (1903) reviewed 38 cases of pneumopericardium, while Gottesman and Bendick (1926) added seven more. The writers have been able to find four other cases in the literature, those of Arrernes (1926), Leys (1926), Molnar (1927), and Imperatori (1928), which make a total of 49 cases. A few of the foregoing cases are the result of spontaneous gas production from infected

pericardial fluid, but the majority of them are the result of traumatic perforation of the pericardium from within or from without, of perforation into the pericardium from a neighboring organ, or the perforation of a diseased pericardium into a neighboring organ.

Pneumopericardium in man, resulting from a perforation of the esophagus due to a foreign body, however, is found less frequently than either pneumopericardium due to penetration of a foreign body through the chest wall, or to a contusion of the thorax. Pneumopericardium in animals, resulting from perforation of the esophagus by a foreign body, is a frequent

<sup>1</sup> Read before the Section on Radiology, Illinois State Medical Society, Springfield, May 18, 1932.

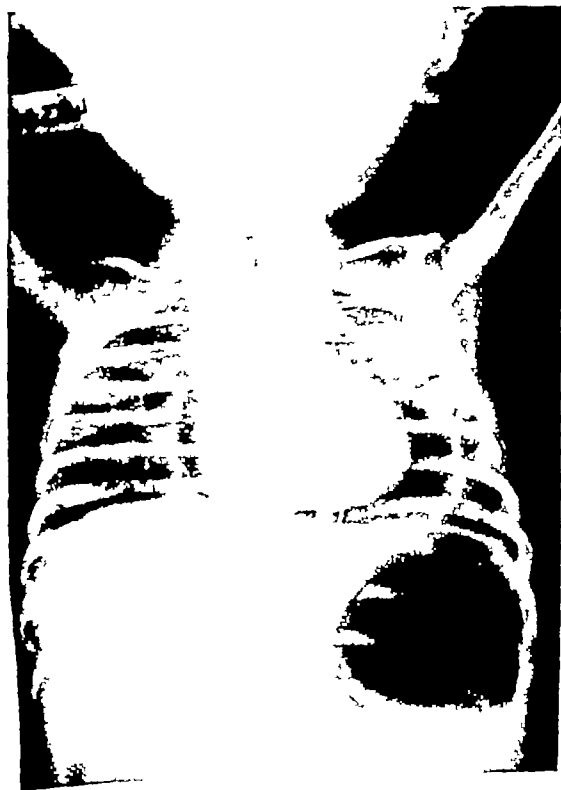


Fig 1-A Anteroposterior projection showing pneumopericardium with open safety pin *in situ*. Note the thickness of the pericardial sac.



Fig 1-B Lateral projection of same case shown in Fig 1-A

finding Imperatori mentions that numerous cases are found in monkeys, induced by biting off and swallowing pieces of barbed wire from their inclosures Brailsford (1929) also states that it is commonly found in cattle sent to the public abattoir, due to swallowing long strips of sharp metal or wire

Only four cases of pneumopericardium resulting from foreign bodies in the esophagus have been noted in the literature by the writers All of these ended fatally Bust (1839) reported a case of pneumopericardium in an adult, the result of swallowing a dental plate This condition, however, was not recognized during life, but was found at autopsy fourteen days later Walsh (1873) reported pneumopericardium from an esophageal wound due to swallowing a sword, which was diagnosed during life, while James (1904) cited a case of pneumopericardium in a girl 25 years of age, resulting from a sliver of bone perforating the esophagus This was diagnosed during life, and at autopsy ten days later two oval openings were found in the esophagus, each 2 cm in length, directly opposite each other, one of which perforated the pericardium In 1928, Imperatori reported a case similar to ours, in an infant 13 months of age, who swallowed an open safety pin An autopsy revealed a pericardial-esophageal fistula

*Clinical History*—W M, eight-months-old infant, entered the Sarah Morris Hospital, service of Dr Jesse R Gerstley, May 22, 1928 A cough which had developed five days previous to entrance, was the chief complaint made by the mother at the time of admission

The following history was also obtained The child had been well until, five months before hospitalization, when there was bleeding from the bowel for a day, followed by tarry stools The passage of bright red blood was seen one month later, this as before being followed by the passage of tarry stools At this time the mother had found the baby "blue, stiff, and seemingly dead" for several minutes Since then



Fig 2 Right oblique projection showing pneumopericardium with barium-filled esophagus and open safety pin at about the level of the esophageal hiatus Note the barium at point of pin and free communication into the pericardium

there had been difficulty in swallowing, an anorexia, and a loss of weight

Physical examination on admission showed an undernourished white child of eight months, with moderate beading of the costochondral articulations There was some impairment of resonance in the left base posteriorly, with the lung fields elsewhere negative The abdomen was flabby and distended The liver was firm, extending 4 cm below the right costal margin The tentative diagnosis was a rachitis of moderate degree, a mild pharyngitis, and a resolving left lobar pneumonia

A roentgenogram, taken because of the probable pneumonia, revealed a pneumopericardium, with an open safety pin lying in the esophagus between the seventh and tenth ribs posteriorly The open end was up and the closed end was at the cardia of the stomach (Figs 1-A and 1-B)

There was an area of increased density in the upper left lung field, suggestive of pneumonia. This finding, however, was not definite (Fig 1-A).

A barium meal, given the same day,

aspect, at the lowest portion, a safety pin was found in the lumen, the bend resting at the point where the esophagus passes through the diaphragm. The pointed end of the erect safety pin had perforated the

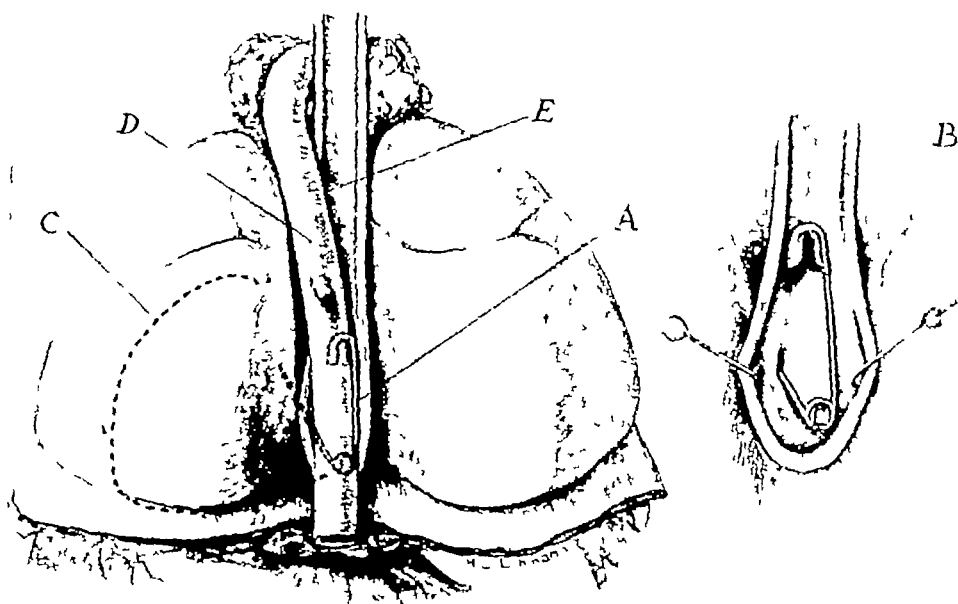


Fig 3 Drawing of autopsy specimen (A) Open safety pin in esophagus with pointed branch penetrating into pericardium, (B) Drawing showing the fistulous tract through the esophageal wall (C) Outline of pericardial sac, (D) Thoracic aorta (E) Esophagus

showed the barium-filled esophagus with the open safety pin at the level of the esophageal hiatus in the diaphragm. Barium was also seen to enter the fistulous tract into the pericardium (Fig 2).

The following day an esophagoscope was passed and an unsuccessful attempt made to dislodge the pin. Roentgenograms showed that the position of the pin had not changed. The child's temperature, which had varied between 101° and 103° F, dropped to 98.6° F. The next day, May 27, 1928, vomiting became projectile, there was marked difficulty in breathing, and the child died.

**Autopsy Report**—The pericardial sac contained 100 c c of cloudy purulent fluid. The visceral surface of the pericardium was covered by a layer of fibrin. Upon opening the esophagus from its posterior

anterior portion of the esophagus, extending to the left, upward and anteriorly and had passed through the mediastinal tissue, with 5 mm of the point lying in a groove on the surface of the heart. The pin had produced a fistula which connected the pericardial cavity and the esophagus (Fig 4). On the surface of the left lung there were several dark areas, non-crepitant and firm. The diagnosis made from the above findings was "Subacute purulent pericarditis. Sinus tract from the pericardial cavity to the esophagus, formed by safety pin in the esophagus."

**Discussion**—The symptoms of pneumopericardium, according to Rigler (1925), are variable and depend entirely upon the etiology. There are two outstanding symptoms—precordial pain and attacks of dyspnea. The signs, however, are con-

stant and unmistakable. On percussion, normal pericardial dullness is replaced by a shifting area of tympany over the precordium. On auscultation, there is a splashing, gurgling, churning sound, the "bruit de moulin," resembling the noise made by a water wheel and synchronous with the heart beat. The heart sounds are diminished. Herschfelder (1918) stated that the percussion note over the cardiac area may vary from bell-like tympany to absolute wooden flatness, and when the opening into the pericardium is of medium size a "cracked-pot" note may be heard. The roentgenogram, however, is the most positive sign and confirms the diagnosis. According to Brailsford (1929), pneumopericardium is rarely diagnosed during life. It may exist, yet its presence may be unsuspected owing to the insidious development during the progress of a grave lesion, or to the fact that the symptoms and physical signs in the primary lesion mask those of this condition.

In cases of pneumopericardium following a foreign body in the esophagus, reported by Walsh and James, the diagnosis was made from the signs of shifting dullness and tympany, together with the characteristic "water-wheel murmur." The case reported by Buist was not recognized during life. No characteristic signs or symptoms were noted in the case reported by Imperatori, the diagnosis being made from the radiograms alone.

In our case there was no history of the child having swallowed a foreign body, not an unusual finding, for infants are seldom seen in the act of swallowing foreign bodies. Foreign bodies, including open safety pins, can be swallowed and remain in the esophagus for from one to five months, and produce no symptoms warranting hospitalization until an advanced pathologic process has been reached. This occurred in our case and also in the similar case of pneumopericardium reported by Imperatori. Two other cases, showing safety pins lodged in the esophagi of children for a month, unsuspected, were also mentioned by Imperatori.

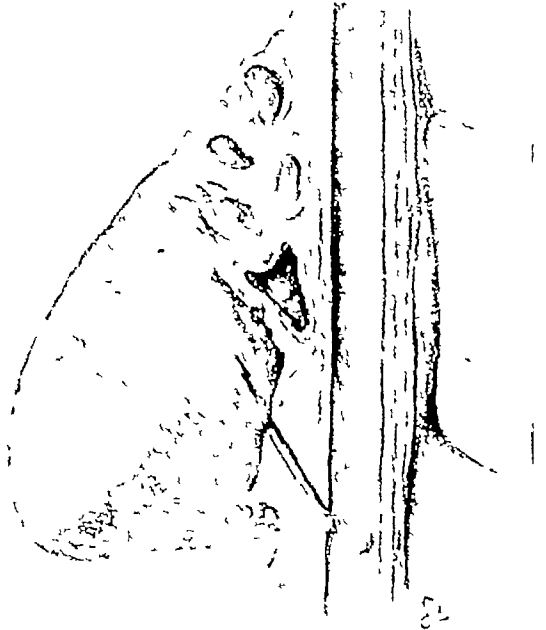


Fig 4 Drawing of autopsy specimen of the heart showing fistulous tract, the result of the pointed branch of the open safety pin penetrating the walls of the esophagus into the pericardium

The presence of bright red blood in the stools, followed by tarry stools, while of grave medical significance, did not cause the mother to seek medical attention for the child. The quantity of blood, too, must have been large, to have given such findings and its presence can be accounted for only by the fact that the pin punctured the wall of the esophagus. The recurrence of blood one month later may be explained by the vomiting, sufficient to produce reverse peristalsis in the esophagus and to break the adhesions which possibly had been formed around the pin.

There was, also, a history of an attack of cyanosis, followed by syncope. The cyanosis, no doubt, was due to embarrassed heart action, resulting from the air in the pericardium. Impaired resonance over the left base posteriorly may be accounted for by the pressure on the lung by the dilated pericardial sac.

The water-wheel murmur expected in pneumopericardium could not be elicited. Whether or not this was due to the prone position of the child at the time of the

examination, the distribution of fluid in the pericardial sac, or the pressure of the greatly dilated stomach against the pericardium, cannot be determined

### CONCLUSIONS

Reported cases of pneumopericardium following a foreign body in the esophagus are very rare—only four cases were noted in the literature by the writers. Three of these were in adults. In infants this condition is even more rare, only one other case having been found. It is probable that the condition is not actually so rare as it appears, since the symptoms and signs are indefinite and often misleading, and are usually diagnosed only from the roentgenologic or autopsy findings. In

this case the diagnosis was made from the roentgenograms, confirmed by the findings at autopsy.

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# BRONCHIAL OBSTRUCTION: ITS DIAGNOSIS AND TREATMENT<sup>1</sup>

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**B**RONCHIAL obstruction is a condition that presents a group of clinical, physical, and roentgenologic findings which appear in a definite sequence, the nature of the finding at any given time being dependent upon the period in the development of the obstruction at the time the condition is being studied. The etiologic factors are varied and numerous, but all may produce some similar changes at corresponding stages in the development of a bronchial obstruction. The cause of the obstruction may lie wholly within the lumen of a bronchus, as in the case of an intrabronchial foreign body, it may originate within the bronchial wall, as in the case of a bronchogenic carcinoma, or it may lie entirely outside the wall of the bronchus in the peribronchial or adjacent tissue, as in the case of an aneurysm, causing compression and obstruction of a bronchus.

There have appeared in the literature numerous articles dealing with bronchial obstructions. For the most part, these articles have dealt with some particular type of obstruction, such as foreign bodies in the tracheobronchial tree, or carcinoma of the bronchus, or they have dealt with some condition which has developed secondarily to the obstruction, such as a massive atelectasia or a drowned lung.

For some time we have directed our thoughts toward bronchial obstruction as an anatomic and physiologic condition rather than toward the etiologic factor or the secondary changes. We have felt that it should be possible to arrive at some general principles which might be of primary importance in establishing a diagnosis of bronchial obstruction in any and all cases of obstructive lesions encountered, and that, having such general principles to work with, one might determine the

proper remedial measures in a much more satisfactory manner. We are of the opinion that to accomplish this end it is only necessary to use the information that has been accumulated by past experiences in such a manner that one will think in terms of bronchial obstruction rather than in terms of any one condition or disease. *We would then become more bronchial-obstruction-minded.*

A considerable proportion of the cases of intrabronchial foreign bodies will present a definite history indicating the possible presence of a foreign body. There is a small group of foreign body cases, as well as a large group of cases in which the obstruction is caused by endobronchial growths and inflammatory processes, together with those in which the obstruction is caused by extrabronchial lesions, in which the historical facts are elicited with difficulty. The ultimate diagnosis in many cases is dependent upon the history of an unexplainable cough or blood-spitting or some other symptoms which may be even more indefinite. This has led to a careful investigation of the physical and x-ray findings and to an ultimate bronchoscopic investigation.

The important physical signs of bronchial obstruction which past experiences have proven to be of importance are herewith listed:

- (1) Limited expansion
- (2) Diminished breath sounds distal to the obstruction
- (3) Altered breath sounds at the site of the obstruction
- (4) Altered vocal fremitus (usually decreased)
- (5) Impaired percussion note

One should bear in mind the fact that, should the obstruction be complete, there may be an interval, before absorption of the air distal to the obstruction has taken place, when the percussion note is tym-

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Fig 1 Reveals a dense shadow in the region of the right stem bronchus, with slight increase in density in the lower portion of the lung-field. Molar tooth was removed at bronchoscopy. The obstruction being incomplete, it had been possible for air to enter and leave this lung and for some excretions to be expelled.

panic, only to be replaced later by a dull and finally by a flat note, as absorption takes place and atelectasis develops. At the same time, evidence of displacement of the mediastinal contents and narrowing of the intercostal interspaces may be elicited. If secretions accumulate distal to the obstruction, the evidence of displacement will not be so marked and the condition may be spoken of as "drowned lung." The distribution of râles varies with the site, the completeness, and the duration of the obstruction.

The roentgenologic findings in the presence of a bronchial obstruction are, likewise, dependent upon the location, the character, the completeness, and the duration of the obstruction.

(1) If the obstruction is incomplete, the lung distal to the obstruction may present evidence of over-inflation by its increased transparency, and it may be noted that the mediastinal contents are

displaced away from the affected side during expiration.

(2) If the obstruction is complete, there will be an increased density over the affected portion of the lung, and, if the air is not replaced by secretion, the mediastinal contents may be shifted toward the affected side. The intercostal interspaces on that side will be narrower and the hemidiaphragm fixed or elevated. If the air is replaced by secretion, the evidence of decreased lung volume will be less marked.

The importance of these general points and some additional ideas can best be emphasized by presenting a group of cases, all of which show some of the earmarks of bronchial obstruction, no two of which are at exactly the same stage in their development and no two are produced by exactly the same lesion, yet all can be grouped as bronchial obstruction. The diagnosis and treatment of the particular condition causing the obstruction were accomplished after all factors associated with it had been taken into consideration.

#### ACUTE INCOMPLETE OBSTRUCTIONS, ENDOBONCHIAL

This type of obstruction is illustrated by the findings in Cases 1, 2, and 3.

Case 1 V. E., nine months of age, six hours before admission to the hospital had choked while eating peanut candy. At first the child was blue in the face but later appeared to be all right. Physical examination revealed a diminished excursion over the lower portion of the right half of the chest. The percussion note was hyper-resonant over this area. The breath sounds were distant over this area and the expiratory murmur was short. The fluoroscopic and x-ray studies revealed an increased translucency of the lower right half of the chest, with the mediastinal contents in a fairly normal position during inspiration, but displaced toward the left during expiration. The removal of one-half of a peanut from the right stem bronchus relieved the symptoms and led to

a correction of the other abnormal findings

Case 2 A boy, 10 years of age, gave a history of having had a tooth extracted under gas anesthesia one week previously. He had not taken a smooth anesthetic and had coughed considerably afterward. Physical examination revealed limited motion over the lower portion of the right lung-field. The percussion note was not materially altered. The breath sounds near the root of the right lung were harsh, but distal to this area the sounds were distant. X-ray and fluoroscopic studies revealed little change, except the presence of a very dense shadow in the region of the right stem bronchus and a slight increase in the density of the lung-field in the lower portion of the field. Bronchoscopic investigation confirmed the diagnosis of an opaque object in the right stem bronchus, with incomplete obstruction, and resulted in the removal of a molar tooth, together with considerable fluid of a sanguino-purulent character (Fig 1)

Case 3 A baby, eight months of age, had choked one hour previous to examination, while playing on the floor, only to recover after a few moments. This was followed by frequently recurring spells of cyanosis and respiratory difficulty. Physical examination at first revealed a child with a normal color which became cyanotic during the examination, only to clear up again. There was, at times, retraction of the infra- and suprasternal notches as well as of the intercostal spaces. At times, there was limitation of motion over one portion of the chest, only to be replaced by a similar limitation at some other point. The percussion note was always resonant. The breath sounds were distant at all times over some or all portions of the lung-field. There was an audible slap over the trachea at times. Fluoroscopic and x-ray studies revealed a movable object in the trachea and bronchi, its position changing from moment to moment. When the object was in the trachea there was increased translucency of both lung-fields, with depression of both hemidiaphragms



Fig 2 In this case there is noted at one instant a very dense shadow in the upper trachea near the larynx and the next instant this same type of shadow is seen to occupy a place in the region of the right stem bronchus. This case illustrates the free movability of certain types of foreign bodies and also serves to emphasize the seriousness of what might seem at the time to be an insignificant accident

and widening of the intercostal interspaces. When the object was in one stem bronchus these changes were noted on only the affected side and it was also noted that during expiration the mediastinal contents, particularly the heart, was shifted toward the uninvolved side. Bronchoscopic investigation confirmed the diagnosis and resulted in the removal of a pearl bead from the trachea (Fig 2)

In this group of cases it will be noted that there is a definite history, giving an indication of the probable presence of a foreign body. The physical signs are not the same in any two of them, yet some similar findings are present in all of these cases. The x-ray findings, likewise, present some similarities. Special attention should be called to the fact that in the case of the boy with the tooth in his bronchus (Case 2) sufficient time had elapsed to permit secretion to accumulate distal to the obstruction. We find, therefore, that there is an increase in density in this portion of the lung-field.

#### ACUTE COMPLETE BRONCHIAL OBSTRUCTION, ENDOBRONCHIAL

This type of lesion can be illustrated by Case 4, a white male, McM, 40 years of



age, who underwent an operation for appendicitis under spinal anesthesia. Six hours later there was an increase in the pulse rate, followed at the end of eight

ance of the air from the lung resulted in a decreased lung volume, with a resultant decrease in the size of the thoracic cage on the involved side as shown by the elevated



Fig 3 Note the marked increase in density throughout the right lung-field, with the retraction of the heart into or toward the right side of the chest, with the narrowing of the intercostal interspaces on the right (Case 4)



Fig 4 Note the disappearance of the shadow of great density throughout the right lung-field with the return of the heart shadow to its normal position. The interval between the two films (Figs 3 and 4) is a short one

hours by an increase in the respiratory rate, and at the end of twelve hours by a rise of temperature. The patient was of a dusky slaty blue color. At this time there was dullness over the right side of the chest, with absent breath sounds and the cardiac impulse was displaced toward the right. The x-ray findings at the end of twenty-four hours showed a great increase in density over the right half of the chest except for a small area near the apex. The intercostal interspaces were narrow. The heart and mediastinum were displaced toward the right. The diaphragm on this side was elevated. A diagnosis of acute post-operative bronchial obstruction was made. Bronchoscopic investigations revealed the presence of a large amount of thick, gelatinous secretion filling the right lower and middle lobe bronchi, the removal of which gave instant relief of symptoms. Likewise, the immediate x-ray findings showed a definite return of the thoracic content toward a normal condition. Here the disappear-

ance of the air from the lung resulted in a decreased lung volume, with a resultant decrease in the size of the thoracic cage on the involved side as shown by the elevated

#### CHRONIC COMPLETE BRONCHIAL OBSTRUCTION, ENDOBRONCHIAL

This condition can be illustrated by Case 5, a boy 11 years, 6 months of age, who had had a cough for seven and a half years. A diagnosis of whooping cough had been made at first, but as the years went by the cough became more and more productive and a very foul odor of the breath developed. In addition, there were frequent bouts of temperature—it rose at times to 103°. No evidence could be elicited of the boy having choked on a foreign body. Physical examination revealed the fact that the lower two-thirds of the right chest was practically immobile. The intercostal interspaces were narrow, tactile fremitus was absent, the percussion note was flat, and the breath sounds were absent. Numerous coarse and fine râles



Fig 5 There is an area of greatly increased density over the right lower lung-field, with some shifting of the heart toward the right side



Fig 6 Same case as shown in Figure 5 Note the presence of a foreign body of the density of metallic quality in the region of the right stem bronchus



Fig 7 Same case as shown in Figures 5 and 6 Note the disappearance of the shadow of metallic density The area of great density extending to the diaphragm on the right has disappeared This change has taken place over an interval of two weeks after relief from the bronchial obstruction by the bronchoscopic removal of a metallic screw from the right stem bronchus

could be heard over the same area and some in the lower portion of the left lung-field, while x-ray studies revealed an area of greatly increased density over the lower portion of the right lung-field. The heart was displaced somewhat to the right and the intercostal interspaces on the right were narrow. In addition to the above findings, fluoroscopic studies revealed the presence of a very dense shadow in the region of the main stem bronchus on the right, further brought out in films and interpreted as being a rusty metal screw. Bronchoscopic investigation confirmed this impression and resulted in the removal of the screw, together with its deposit of rust. Within two weeks the cough and sputum had almost entirely disappeared and the physical and x-ray findings were approaching the normal. In this case we can see the same evidence of decreased lung volume as was seen in the case of an acute complete bronchial obstruction (Case 4). Here we find that numerous râles have replaced the quiet lung of the other case, which can be accounted for by the

fact that there has accumulated much purulent secretion in this lung. In other words, we are dealing with a "drowned lung" (Figs 5-7).

#### COMPLETE OBSTRUCTION OF SMALL BRONCHI, ENDOBRONCHIAL

This type of lesion can be illustrated by a group of cases.

Case 6 A youth, 22 years of age, came complaining of a non-productive cough, temperature up to  $101^{\circ}$ , and a discomfort in the right lower half of the chest, posteriorly, symptoms which had developed during the previous seven days. Physical examination revealed a limitation of motion over the right lung-field in its lower and posterior portions. There was an impaired percussion note near the spine at the right base posteriorly, and the breath sounds were absent over a



Fig 8 Note the area of increased density in the right lower lung-field, extending downward toward the diaphragm but occupying a medial position. There is no noticeable narrowing of the intercostal interspaces, but the diaphragm is slightly elevated.



Fig 9 Same case as shown in Figure 8. Upon bronchoscopic removal of peridental membrane the shadow of increased density in the lower medial portion of the lung field has disappeared and the diaphragmatic shadow is in a lower position.

corresponding area. A few râles could be heard. X-ray studies revealed an area of increased density which corresponded with the area over which the physical signs were altered. The fluoroscopic studies revealed also a limitation of the movement of the diaphragm on the right, with a slight shifting of the heart toward the right during inspiration. Further studies of the history brought out the fact that the patient had had a tooth extracted ten days previous to the time these studies were made. Bronchoscopic studies confirmed the diagnosis of a plugged secondary bronchus and resulted in the removal of a portion of peridental membrane from a right postero-medial bronchial division. Twenty-four hours later the temperature was normal and the other findings, including the x-ray findings, were approaching the normal (Figs 8, 9).

Again we might point to the case of a girl (Case 7), seven years of age, who gave a history of having undergone a tonsillectomy ten days previously. On the third post-operative day her temperature had risen to  $100^{\circ}$  and had ultimately reached  $105^{\circ}$ , with marked malaise and general prostration. There was a non-productive cough. Physical examination revealed a limited excursion over the lower portion of the right lung-field, an impaired

percussion note, a few râles near the midline, and the absence of breath sounds over the same area. Fluoroscopic and x-ray studies revealed an area of increased density over the same area, a shifting of the heart toward the right on inspiration, and partial fixation of the right hemidiaphragm. Bronchoscopic investigation confirmed the diagnosis of obstructed right secondary bronchus and resulted in relief from an inflammatory obstruction, distal to which a considerable amount of secretion had accumulated. Cultures revealed the presence of streptococci. Twelve hours later the temperature was  $99^{\circ}$ , and physical and x-ray findings were returning to normal.

There is the case of a girl (Case 8), seven years of age, who gave a history of having been ill with fever and cough over a period of several weeks. Her physician had treated her at first for an unresolved pneumonia. When seen, there was limitation of motion of the chest over the lower left lung-field. Fremitus was decreased over an area in the lower part of the left chest posteriorly. The percussion

note was impaired over this same region and the breath sounds were absent. X-ray studies revealed an area of increased density on the left near the hilum, with a gradual fading of the density as the distal portions of the field were approached. The movements of the lower chest wall and of the diaphragm on the left were restricted, and the heart shadow was seen to shift to the left slightly during inspiration. Bronchoscopic studies revealed the fact that the mucosa of one medial division of the left lower bronchus was very much swollen and completely closed the lumen. Much secretion was released when the obstruction was relieved. Cultures revealed the presence of streptococci. The symptoms and x-ray findings immediately cleared up (Fig 10).

Finally, a boy 10 years of age (Case 9) gave a history of choking thirty minutes previously while he had a straight pin in his mouth. The pin disappeared. Physical examination revealed suggestive limitation of motion over the lower portion of the right lung-field posteriorly. No change in percussion note or tactile fremitus was noted. Breath sounds were disturbed very little, if at all. X-ray and fluoroscopic studies revealed the shadow of a pin in the lower right lung-field near the spine, with very little, if any, alteration of the density of this portion of the lung-field. The movements of the diaphragm were limited. Bronchoscopic investigation confirmed the diagnosis of endobronchial foreign body, tertiary bronchus, and resulted in the removal of a straight pin, with complete and immediate recovery of the patient (Fig 11).

The changes noted in this group of cases may be less marked than those previously described, but the fact must be borne in mind that the area of lung involved is much less. It should especially be noted that in the case of the pin in a tertiary bronchus (Case 9), the very short interval which had elapsed between the time of the accident and the making of these studies was not sufficient for the air to be absorbed beyond the obstruction.

Bronchial obstruction due to lesions arising in the walls of the bronchus is illustrated by some cases of bronchogenic carcinoma.

Case 10. A white male, 31 years of age, gave a history of a non-productive cough and of blood spitting at intervals over a period of two years, with some lassitude and, in recent months, slight loss of weight. There was a feeling of respiratory restraint and a discomfort in the lower central portion of the chest. Physical examination revealed one area in the left lower chest, posteriorly near the midline, where the breath sounds had a very harsh bronchial quality. Distal to this area the breath sounds were faint. The x-ray studies gave no additional information. Bronchoscopic investigation revealed the presence of a small nodular mass projecting into the lumen of the stem bronchus from the orifice of a posterior medial division. It was noted that the orifice of this bronchus was fixed. Microscopic studies of this tissue confirmed a diagnosis of carcinoma. Deep x-ray therapy, together with the use of radium at the site of the lesion, resulted in relief of symptoms for four years.

Case 11. White female, 45 years of age, who complained of a non-productive cough, some shortness of breath, and slight loss of weight over a period of six months. Physical examination revealed some limitation of motion over the lower right half of the chest and at a point near the root of the right lung, at which the breath sounds were very high-pitched, distal to this point the breath sounds were somewhat suppressed. At times, coarse râles could be heard in the lower portion of the right chest. X-ray studies revealed the presence of an area of great density near the root of the right lung, with considerable increase in the density of the lung-field distal to this area, the heart was shifted to the right and the intercostal interspaces were narrowed, the diaphragm was elevated. Bronchoscopic examination revealed the presence of a mass in the right stem bronchus, which caused an incomplete obstruction and at the same time it

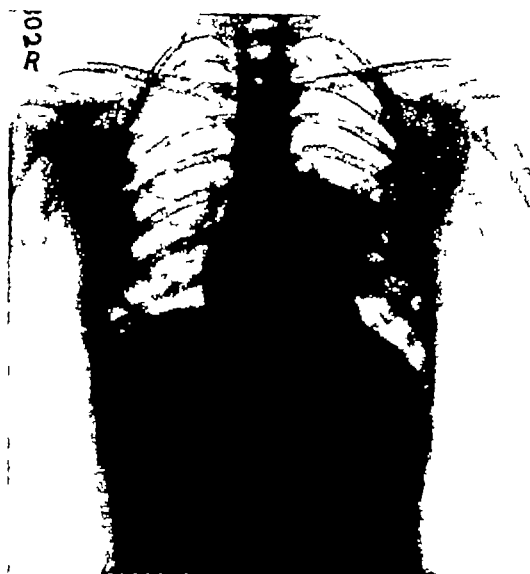


Fig 10 Note the area of increased density extending from the root of the left lung downward along the border of the heart. This corresponds with the area of which physical signs showed a disturbance.

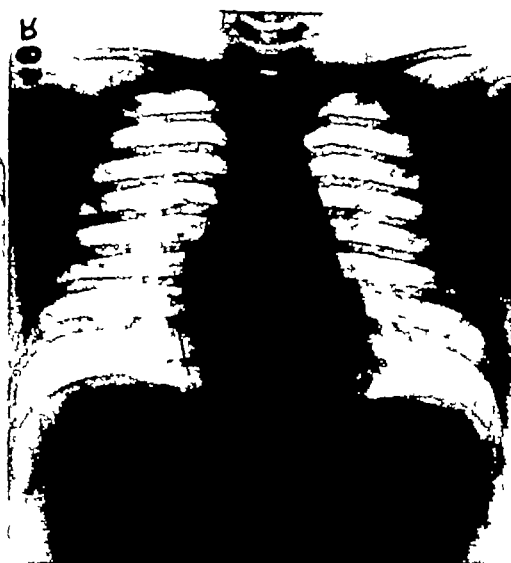


Fig 11 Note a shadow of metallic density at the right base with one end resting almost on the diaphragm and falling within the shadow of the heart. There is practically no disturbance in the translucination of this lung-field.

was noted that the lumen of the bronchus at this point was of a constant diameter, with no increase in diameter during inspiration or decrease during expiration. Microscopic sections confirmed the diagnosis of carcinoma. Within one month the bronchial obstruction became complete and the physical signs and x-ray findings became those of a complete obstruction, with an accumulation of secretion distal to the obstruction.

**Case 12** Another case which further illustrates this type of obstruction is seen in a white male, 35 years of age, who gave a history of a non-productive cough, with some loss of weight, extending over a period of six months, together with some spitting of bright red blood during the previous two weeks. Physical examination at that time revealed some limitation of motion over the lower half of the left chest. The percussion note and tactile fremitus were near normal in quality, but near the left hilum there was a point at which the breath sounds were high-pitched and harsh. No râles were heard. X-ray studies at the time revealed the presence

of an area of greatly increased density near the left hilum (Fig 12).

Six months later the patient was seen again and at that time the chest over the lower left lung-field was immobile and narrower than on the right. Tactile fremitus was absent. The percussion note was flat over this area. The heart sounds could not be heard to the right of the sternum and there were no breath sounds over the lower left. X-ray studies revealed an area of greatly increased density over the left lower lung-field, with a shifting of the mediastinal contents, including the trachea, to the left. Bronchoscopic investigation revealed the presence of a mass completely filling the left stem bronchus, a large portion of which mass was removed. It was noted that the passage thus established was of a constant size during both inspiration and expiration. Microscopic studies confirmed the diagnosis of oat-cell carcinoma. Deep x-ray therapy, together with the endobronchial use of radium, have resulted during the past three months in the disappearance of the local evidence of the mass, together



Fig 12 Note the shadow of increased density in the region of the left hilum (Case 12)



Fig 13 Same case as shown in Figure 12, film made six months later. Note the greatly increased density over the entire left lung-field, with the disappearance of the heart shadow and the displacement of the trachea toward the left, with the narrowing of the interspaces on the left

with increasing mobility of the bronchial wall at the site of the lesion. There remain some harsh qualities to the breath sounds over the site of the lesion. The x-ray studies reveal the fact that the area of greatly increased density has almost entirely disappeared and the trachea has shifted back to its proper position.

air entering this portion of the lung than can leave it. We should also note that with the clearing up of the local

We should note especially the fact that the symptoms in this group of cases are very much less distressing than one might expect them to be, when produced by such serious lesions. Of special importance is the fact that in this group of cases we have not noted evidence of obstructive emphysema, whereas in the cases of intra-bronchial foreign bodies such a finding was common. We would explain this phenomenon by pointing out the fact that in this group of cases we find the lumen of the bronchus at the site of the obstruction to be of a constant size and that air leaves the lung through this passage as readily as it enters. So although the lumen of the bronchus is narrow, as we look at it, still, because of the fact that the normal physiologic narrowing of expiration is eliminated, we have no more



Fig 14 Same case as shown in Figures 12 and 13. Photomicrograph of a section from the bronchial wall showing the great infiltration of this wall with cells of the carcinoma as well as the proliferation of the connective tissue. This explains the fixation of the wall of the bronchus so that all mobility is lost.

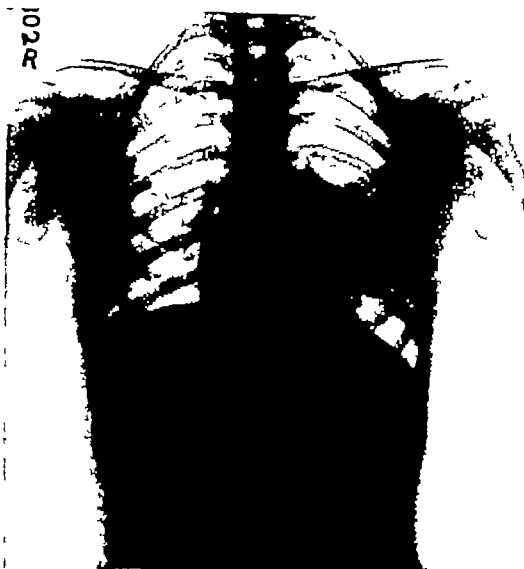


Fig 10 Note the area of increased density extending from the root of the left lung downward along the border of the heart. This corresponds with the area of which physical signs showed a disturbance.

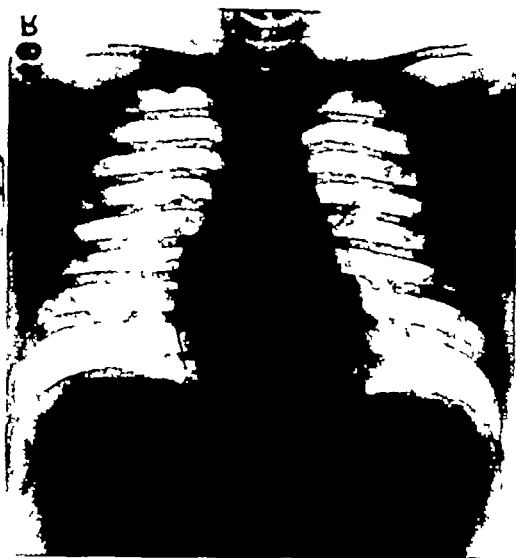


Fig 11 Note a shadow of metallic density at the right base with one end resting almost on the diaphragm and falling within the shadow of the heart. There is practically no disturbance in the transillumination of this lung-field.

was noted that the lumen of the bronchus at this point was of a constant diameter, with no increase in diameter during inspiration or decrease during expiration. Microscopic sections confirmed the diagnosis of carcinoma. Within one month the bronchial obstruction became complete and the physical signs and x-ray findings became those of a complete obstruction, with an accumulation of secretion distal to the obstruction.

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with blood-spitting. The sputum was negative for tubercle bacilli and the serologic studies were negative. Physical examination revealed a fixation of the chest over the right lung-field, the tactile fremitus was much decreased and the percussion note was dull, while many râles could be heard. X-ray studies revealed a great increase in density over the corresponding area, with some displacement of the mediastinal contents toward the affected side. Bronchoscopic studies revealed the fact that the bronchial mucosa was intact and was bathed in much purulent secretion. The lumen was obliterated by a dingy in of the bronchial wall from in front and to the lateral side. A diagnosis of bronchial obstruction due to pressure from without was made, an opinion which postmortem findings confirmed, also revealing the presence of large masses of tuberculous lymph glands as the offending factor.

In this group of cases, changes in the lung-fields are likely to develop somewhat later and will be due chiefly to accumulation of secretion and to secondary infection. Because of the flexibility of the bronchial wall and its ability to adapt itself to its altered surroundings, complete obstruction is usually much delayed.

#### SUMMARY

We have presented a group of cases illustrative of the different types of bronchial obstructions, together with the important historical, physical, roentgenologic, and bronchoscopic findings. In each case it has been possible to establish a working diagnosis of bronchial obstruction without regard to the causative agent

The selection of remedial measures has been dependent upon the establishment of the etiologic factors.

#### CONCLUSIONS

1. Bronchial obstruction can be dealt with as a definite entity.
2. The causative influences are varied and may lie within the bronchial lumen or within the wall of the bronchus, or may be entirely extrabronchial.
3. The treatment must be varied in

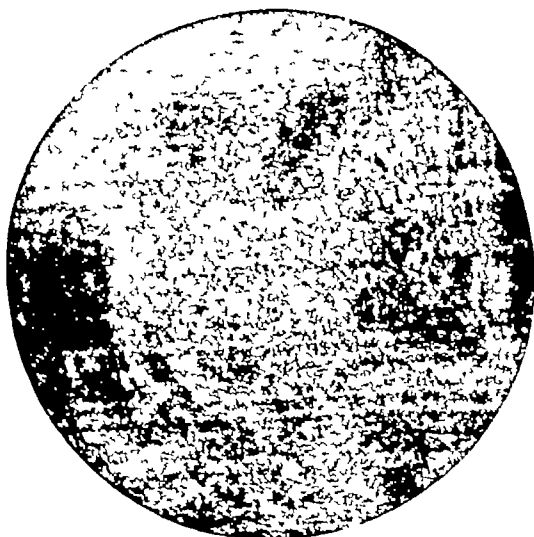


Fig 17. Same case as shown in Figure 16. Photomicrograph of a section of an extrabronchial gumma removed at postmortem.

accordance with the causes concerned.

4. Early diagnosis and treatment are highly essential and good results are dependent upon one's ability to relieve or remove the etiologic factors.



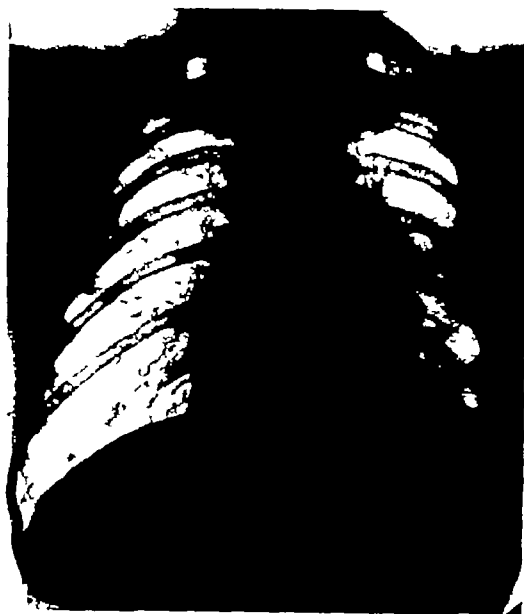


Fig 15 Same case as shown in Figures 12-14. After x-ray and radium treatment the greater portion of the findings shown in Figures 12 and 13 have disappeared. There has been a shifting of the heart shadow back toward the normal position.



Fig 16 Note an area of increased density extending from the right root outward and downward (Case 13)

infiltrative lesion the normal physiologic peristaltic action of the bronchial muscles returns. We might add that we are confident this is true in all cases in which the muscle fibers have not been too greatly destroyed.

#### EXTRABRONCHIAL LESIONS, WITH PARTIAL OBSTRUCTION

This type of lesion is illustrated by the report (Case 13) of a white male, 63 years of age, who had gradually lost weight during an interval of about three months. There had been increased lassitude and weakness, together with a cough that at first was non-productive, but toward the last was productive of considerable quantities of purulent secretion. There was considerable cyanosis. The temperature was variable. Serologic studies revealed a positive Wassermann. Physical examination revealed some immobility of the chest over the lower right lung-field, tactile fremitus was present, the percussion note was dull, and the breath

sounds were bronchial in character, but they were somewhat suppressed. Numerous coarse râles could be heard throughout the lower right lung-field. X-ray studies revealed the presence of an area of increased density extending from the right hilar region to the periphery and downward, with the outer margin of the field having considerable translucency, while the heart seemed to be shifted to the right. Bronchoscopic investigation revealed the fact that the bronchial mucosa was intact although moderately inflamed, and was bathed in considerable quantities of purulent secretion, while in addition, there was a dingy in of the wall of the lower stem bronchus from its lateral and anterior aspect. A diagnosis of bronchial obstruction due to pressure by a mass on the outer wall was made, an opinion which postmortem findings confirmed. Microscopic sections from the mass established the diagnosis of a peribronchial gumma.

Another example of obstruction due to a lesion outside the bronchus is seen in the findings in Case 14, a white male, 43 years of age, who had been losing weight for a year and had a productive cough,

an event, the remaining walls, floor, and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending upon the circumstances." The American Recommendations, which are considerably more elaborate, contain, in detail, provisions for the protection from scattered radiation of therapeutic apparatus, up to 250 K V, dividing them into two groups Class B, up to 140 K V peak, and Class C, from 140 to 250 K V peak.<sup>2</sup> However, as yet no mention has been made of the protective requirements for installations above 250 K V peak. From a study of the rules of the Class C installation, and by applying the higher lead thickness values as expressed in Table I, one may, by inference, be able to deduct certain safety rules for apparatus above 250 K V peak, but only experience will furnish the necessary practical data proving these rules.

Having more than a year ago installed in Harper Hospital a roentgen-ray apparatus capable of operating at 700 K V constant, we had the opportunity to experimentally study the most suitable protective measures against the radiation emitted by such a powerful installation. On the basis of the data accumulated so far, we would like to present at this time some practical conclusions concerning the radiation protection, as well as the safeguards against electrical accidents, and some protective measures of a more generalized character, such as ventilation, air ionization, *et cetera*. For the sake of convenience, and to conform as much as possible to the classification and terminology used by the Advisory Committee on X-ray and Radium Protection (as expressed in Handbook No. 15 of the Bureau of Standards), we will divide our subject, which deals with very short wave roentgen-ray installations at voltages from 250 K V to 1,100 K V, as follows:

#### I Protection from roentgen rays

##### (a) Protection from direct radiation,

- (b) Protection from scattered radiation originating from treatment cell,
- (c) Protection from stray radiation originating from machine plant room

#### II Electrical protection

#### III General protection

#### I PROTECTION FROM ROENTGEN RAYS

##### (a) *Protection from Direct Radiation* —

For the protection against the harmful effect of direct radiation generated with voltages up to 250 K V peak, both the International and American Recommendations specify that the roentgen tube must either be completely surrounded or enclosed in a protective material of lead equivalent value which corresponds to the figures of Table I. The American Recommendations, in addition to this, provide that a sheet of lead, of thickness in accordance with Table I, shall be placed in the path of the direct or useful beam on the floor, wall, or ceiling opposite the diaphragm, and made to extend one foot in all directions beyond the border of the roentgen-ray beam, which is determined by the largest possible aperture in the tube enclosure. In case the radiation is taken off in several directions, and there is any doubt as to the limits of the beam, the whole room should be lined with lead in accordance with Table I.

By trying to apply the above specifications to the short wave radiation, generated by voltages between 250 K V and 1,100 K V peak, it becomes evident that two difficulties will prevent their rigid enforcement. First of all, it is practically impossible to completely surround or enclose the roentgen-ray tube with protective lead, which would be adequate to shield off direct radiation in all directions, and secondly, the lining of an ordinary treatment room, in part or in its entirety, with such large quantities of sheet lead as to afford the required protection against all radiation (direct and, as we shall see later, scattered), creates new elements of construction.

<sup>2</sup> Class A, representing the installations used for diagnostic purposes with voltage up to 130 K V peak

# THE PROBLEMS OF PROTECTION AND THEIR SOLUTION IN SHORT WAVE ROENTGEN THERAPY<sup>1</sup>

By T LEUCUTIA, M D , *Associate Roentgenologist, and* K E CORRIGAN, PH D , *Physicist, Harper Hospital, Detroit, Michigan*

THE International Recommendations for roentgen-ray and radium protection, which were elaborated at the Second Congress of Radiology, in Stockholm, in 1928, and revised at the Third Congress, in Paris, in 1931, are now observed by most roentgen-ray and radium workers throughout the world. These Recommendations are also steadily assuming increasing importance with various lay organizations, such as hospital boards, insurance companies, health agencies, etc., whenever the question of application of roentgen rays or radium is being considered. More recently, the health committee of the League of Nations, by collecting from the literature a bibliography of between five and six hundred articles and assembling all the protective measures adopted by the various countries, issued a most comprehensive pamphlet dealing with the subject.

In America, an Advisory Committee on Roentgen-ray and Radium Protection was formed shortly after the International Congress, at Stockholm, in 1928. This Committee is composed of two members of each radiological society, two members appointed by the manufacturers of x-ray equipment, and one by the American Medical Association, the Chairman being Lauriston S. Taylor, of the International Safety Committee and National Bureau of Standards. After much laborious work, the Committee prepared "a unified set of safety recommendations" for the United States, and published them, in 1931, in the form of a book called "Handbook No. 15, of the Bureau of Standards."

In analyzing these Recommendations, from the standpoint of protection from the short wave roentgen rays emitted by high voltage apparatus above 200 K V peak,

which have begun to occupy such an important part in the realm of radiation therapy during the last two years, we find that they are as yet inadequate. This is shown in Table I.

TABLE I

International Recommendations		American Recommendations	
X-rays generated by peak voltages	Min equivalent thickness of lead	X-rays generated by peak voltages	Min equivalent thickness of lead
Not exceeding K V	Mm	Not exceeding K V	Mm
75	1 0	75	1 0
100	1 5	100	1 5
125	2 0	125	2 0
150	2 5	150	2 5
175	3 0	175	3 0
200	4 0	200	4 0
250	6 0	225	5 0
300	9 0	300	9 0
350	12 0	400	15 0
400	15 0	500	22 0
		600	34 0
		900	

Provision is made for the protection against direct radiation, the equivalent lead thickness values being extended in the International Recommendations up to 400 K V peak, and in the American up to 600 K V peak, but the protection against the scattered radiation from the walls of the treatment room or patient, and especially against the stray radiation produced by various sections of the roentgen-ray tube, thus latter reaching formidable proportions with increasing voltages, is completely omitted. All that the International Recommendations provide in this respect is "In the case of x-ray treatment, the operator is best stationed completely outside of the x-ray room behind a protective wall of a minimum lead equivalent of 2 millimeters. This figure should be correspondingly increased if the protective value of the x-ray tube enclosure falls short of the values given in Table I. In such

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept 25-30 1933

lead of the desired thickness (1-inch up to 500 K V , to 2-inch up to 900 K V , etc ) Both the steel tank and the narrower steel cylinder being grounded, the sheet lead can be brought very close On the steel

the generating apparatus through the entire length of the tube, ends freely within the steel tank, barely 20 inches away from the target In this manner, the roentgen rays are generated entirely within the pro-

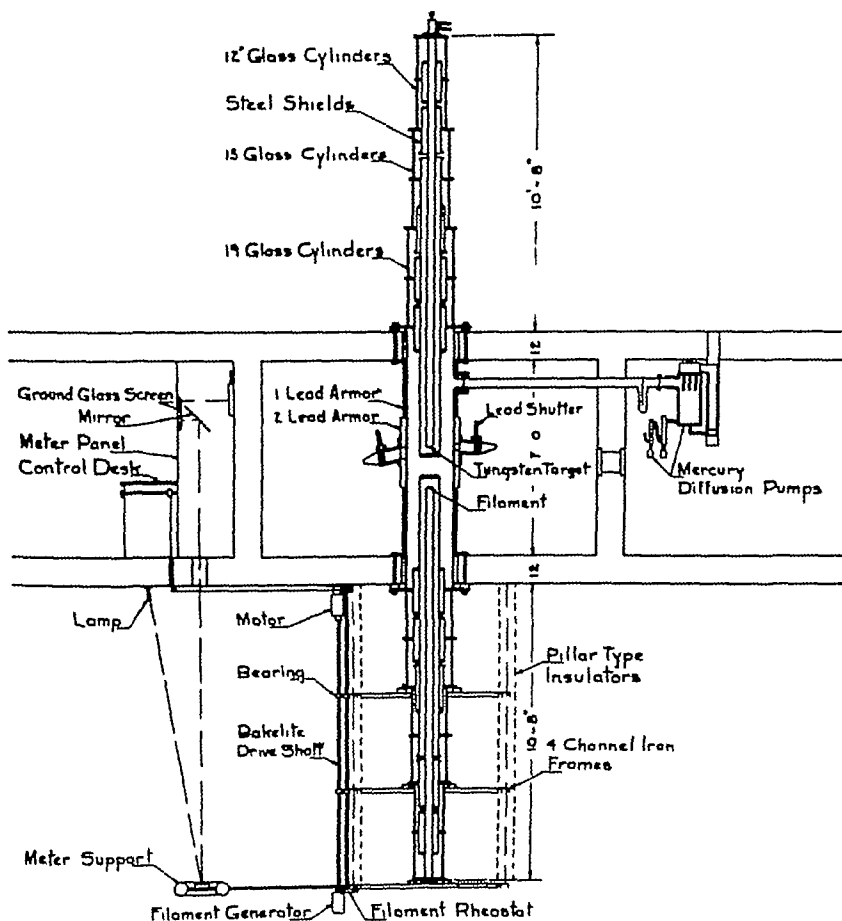


Fig 2 Lauritsen's centrally protected x-ray tube of 1,100 K.V  
(Kellogg Radiation Laboratory of the California Institute of Technology)

cylinder, the sheet lead lies directly on the cylinder's outer surface, whereas on the narrower cylinder, a small interspace is allowed, the protective lead being molded in the form of a cap Inasmuch as the target, which in our tube is at  $45^\circ$ , forms the end of the narrower cylinder, one or several suitable apertures can be provided in the lead cap, allowing the useful radiation to emerge It may be mentioned here that the filament in our tube is on the spherical end of a steel holder which, after traversing from the high potential end of

ected end of the tube, which, as mentioned above, projects into the leaded treatment cell

In the type of tube in which the roentgen-ray emission is in the middle of the tube, a protective sheet lead enclosure is affixed to this portion Figure 2, which shows the installation at the Kellogg Radiation Laboratory of the California Institute of Technology, illustrates a vertical tube arrangement in which the central portion of the tube is surrounded by a 2-inch sheet lead cylinder (at 900 K V ),

The first difficulty largely resolves itself into a problem of tube design. It has already become the tendency in recent years to build the protective material of a roentgen tube directly into the wall of the

or a Lauritsen tube from 10 to 30 feet long, with the equivalent lead thickness which, at 1,100 K V peak, would be in the neighborhood of 3 inches of sheet lead, would mean the use of thousands of tons of lead,

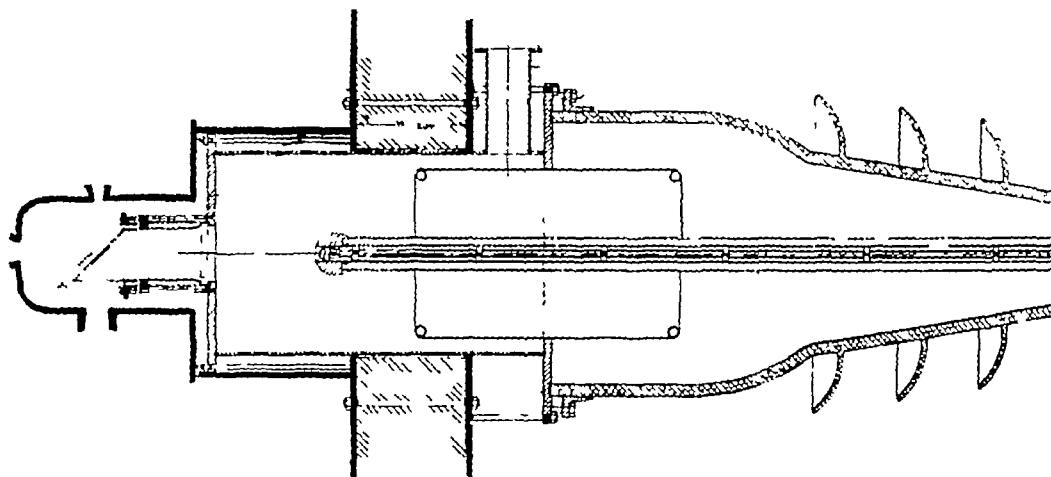


Fig 1 Lauritsen's porcelain x-ray tube of 700 K V and its lead protection (heavy line indicating sheet lead)

tube so as to reduce the size of the outfit, and there are now numerous tubes, especially in the roentgen diagnostic field, which make use of this principle. In the therapeutic field, where the tube must be of considerably greater dimensions and, therefore, large quantities of protective material would be needed to produce a complete shielding off of the radiation, the incorporation of the protective material into the tube itself becomes, with increasing voltages, a matter of necessity. Up to 250 K V peak, it is yet possible to enclose the entire roentgen tube in a large lead box or drum as specified in the protective recommendations. However, as soon as the capacity of the tube is increased beyond that voltage, its dimensions start to assume such formidable proportions that a complete surrounding with equivalent lead, which *per se* has to be increased because of the greater penetration of the rays, becomes a practical impossibility, or, to say the least, a problem of tremendous practical disadvantage. To surround, for example, a 14-foot, 3-sectional Coolidge tube,

especially if one takes into consideration the high electric clearance necessary at such high voltages

In the following, we will present our tube arrangement, which permits the solution of the radiation protection problem in a rather simple manner. *A priori*, we would like to state, however, that it is not the purpose of this article to enter into a detailed description of the tube construction proper, for this can be found elsewhere. It is our desire to briefly discuss only that phase of the construction which refers to the building in of the radiation protection material. As shown in Figure 1, it is a Lauritsen tube making use of porcelain in the form of a conical transformer bushing instead of the usual glass for wall material. The porcelain is joined into a steel tank, which projects through the lead wall into the treatment cell and terminates in the form of a narrow cylinder at the roentgen-ray emission end of the tube. It is now possible completely to surround the steel tank and the roentgen-ray emission end of the tube, from the lead wall on, with sheet

lead of the desired thickness (1-inch up to 500 K V, to 2-inch up to 900 K V, etc.) Both the steel tank and the narrower steel cylinder being grounded, the sheet lead can be brought very close. On the steel

the generating apparatus through the entire length of the tube, ends freely within the steel tank, barely 20 inches away from the target. In this manner, the roentgen rays are generated entirely within the pro-

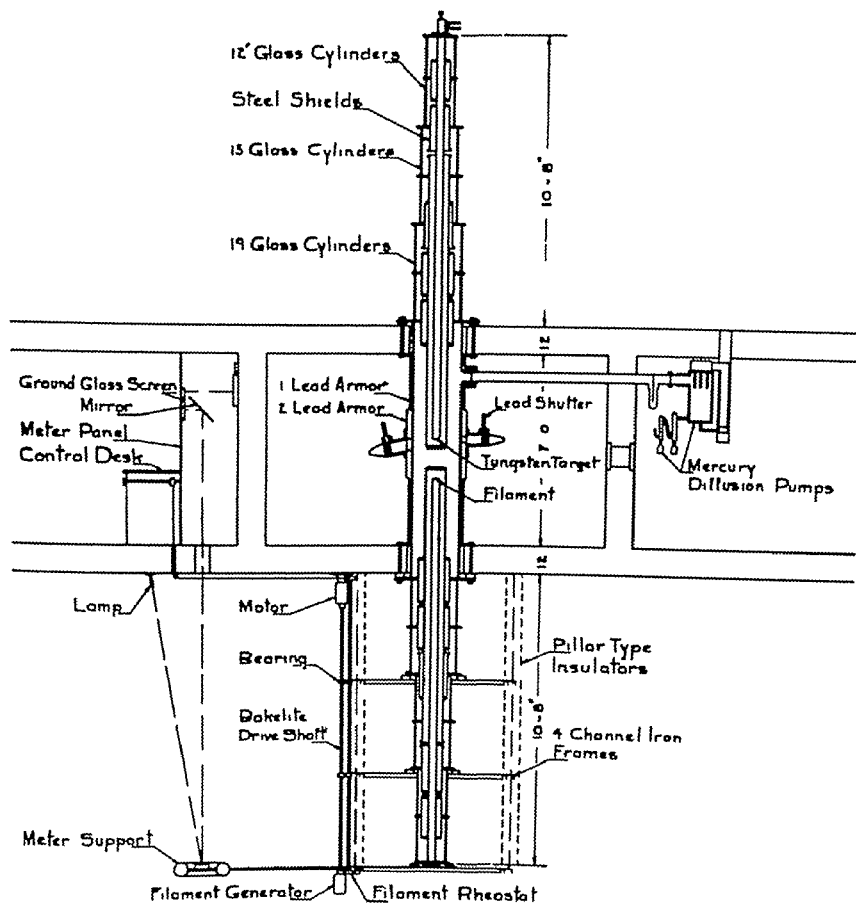


Fig 2 Lauritsen's centrally protected x-ray tube of 1,100 K V  
(Kellogg Radiation Laboratory of the California Institute of Technology)

cylinder, the sheet lead lies directly on the cylinder's outer surface, whereas on the narrower cylinder, a small interspace is allowed, the protective lead being molded in the form of a cap. Inasmuch as the target, which in our tube is at  $45^\circ$ , forms the end of the narrower cylinder, one or several suitable apertures can be provided in the lead cap, allowing the useful radiation to emerge. It may be mentioned here that the filament in our tube is on the spherical end of a steel holder which, after traversing from the high potential end of

ected end of the tube, which, as mentioned above, projects into the leaded treatment cell.

In the type of tube in which the roentgen-ray emission is in the middle of the tube, a protective sheet lead enclosure is affixed to this portion. Figure 2, which shows the installation at the Kellogg Radiation Laboratory of the California Institute of Technology, illustrates a vertical tube arrangement in which the central portion of the tube is surrounded by a 2-inch sheet lead cylinder (at 900 K V),

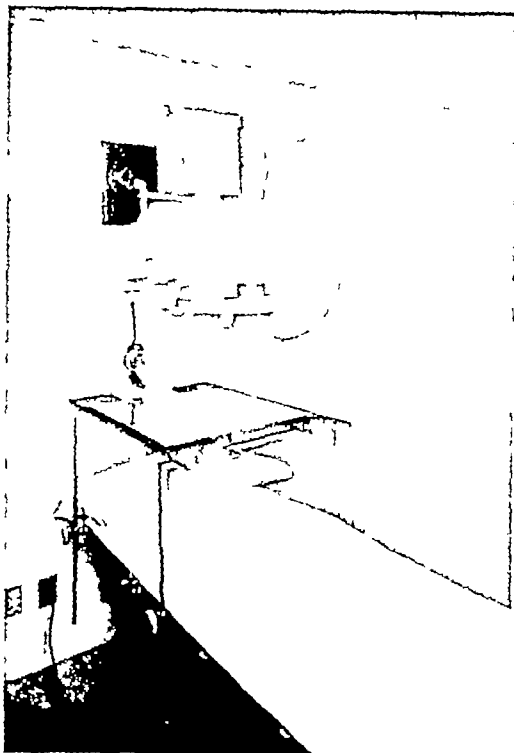


Fig 3 Interior of leaded treatment cell, when roentgen ray emission is from the end of the tube

four apertures being provided for the simultaneous treatment of four patients by the radiation emitted from one single target. The apertures are placed at a  $45^\circ$  angle so as to direct the roentgen-ray beam toward the corners of the treatment cell, thus affording additional protection. The entire tube is 30 feet long, the treatment cell being suspended around the leaded central portion, which is grounded. Of course, there are other possible tube arrangements. A tube, with ray emission at one of its lead shielded ends, may project vertically through a ceiling into a treatment cell which is underground, having concrete as protective material of its walls. Likewise, a centrally protected roentgen-ray tube may lay horizontally and the rays may be taken off through four apertures into four individual treatment cells, one being above, one below, and two laterally, from the tube, *et cetera*.

The second difficulty leads to the neces-

sity of constructing a special treatment cell of the smallest dimensions possible, so that all of its walls can be completely covered with sheet lead or its equivalent. It is advisable that this cell be immediately adjacent to the machine plant, so that the roentgen-ray tube can be built into one of its walls. To prevent the escape of any radiation, all joints, holes, or openings, which are made in the lead wall, must be carefully covered by an equal thickness of lead. In our installation, the walls of the treatment cell (Fig 3), which is  $6 \times 9 \times 12$  feet inside, are lined with 1-inch lead plates, a double thickness being provided in the wall opposite the end of the x-ray tube and toward the control room. These plates are welded, and a 1-inch overlap is provided for all joints, the floor and ceiling are also protected with two inches of lead. All of the walls are without any kind of opening, with the exception of very small holes for instrument cables, carefully plugged and overlapped with lead. An air duct enters the room at the floor in one corner, and a similar duct leaves the room near the ceiling on the opposite side, to connect to a large exhaust fan. The internal orifices of these ducts are constructed of lead baffle plates (one inch in thickness) which overlap. Through these ducts, the entire volume of air in the room can be changed in four minutes and provision is made for controlling the temperature of the air. All openings are remote from the roentgen tube, and at such angles as to be impenetrable to direct radiation in any case. The room is provided with a polished hardwood floor, and the walls are finished with beaverboard and plywood. In this way, sufficient organic material is provided so that the secondary radiation is considerably reduced, the only source of a measurable amount of it being the spot on the floor under the head of the tube where the primary beam strikes the floor. The patient is protected from this beam by the base and the body of the table, which are both of wood.

Access is gained to the treatment cell through a narrow passage, provided at

each end with leaded doors. The doors into the transformer room also carry lead plates, in fact, all of them overlap at the joints, jambs, and sills

must be so arranged that the useful beam does not point toward the operator. In our installation, this wall is partly of concrete, and covered to a height of 8 feet

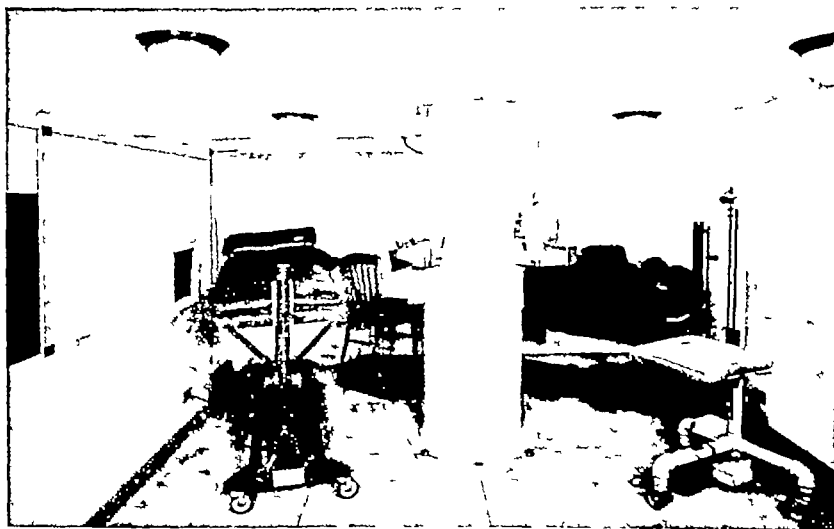


Fig. 4 Interior of leaded treatment cell, when roentgen-ray emission is from the central portion of the tube

Figure 4 shows the treatment cell of the Kellogg Radiation Laboratory of the California Institute of Technology, suspended in a concentric manner around the lead-shielded central portion of the roentgen-ray tube. The walls of this cell are constructed of concrete, 1 foot thick, which is equivalent to a 1-inch sheet of lead. The treatment is carried out through four apertures simultaneously: two of the patients receive irradiation while lying on couches, and the other two while sitting in chairs.

(b) *Protection from Scattered Radiation*—The construction of treatment cells, with adequate lead walls and built-in ray emission ends of the roentgen tube, also takes care of all scattered radiation emanating from the walls of the treatment cell or patient. Of course, all control apparatus must be located in a separate room, where the operator sits. The walls near the treatment cell, and, as we shall see later, the machine room, must receive additional reinforcements either by concrete or sheet lead, and the roentgen tube

with 1-inch lead plates welded and overlapped as in the treatment cell. To completely eliminate any leakage of scattered radiation, we have installed a periscope, instead of the usual lead glass window, for observation of the patient. This instrument has an objective lens which fits into a hole, only 0.5 inch in diameter, in the wall of the treatment cell and is provided with two 90° bends before penetrating the wall of the control room, allowing for adequate baffling. The patient and operator communicate with one another by means of microphones fitted with loud speakers, the wires of which are led through the baffled air ducts.

(c) *Protection from Stray Radiation*—Under the term "stray radiation" we wish to designate all radiation which is produced within the generating room, and which, in the very high voltage apparatus, may reach formidable proportions. The sources of this radiation are manifold: part of it originates from the back-scattering of the roentgen rays from the target, another



part is generated by the electrons hitting various parts of the roentgen-ray tube, especially if there is a great distance between the cathode end (filament) and target, as in the multisectional tubes, and, finally, a third part is produced by the thermionic rectifiers, in the installations in which such tubes are used for rectification. It is evident that many of these rays must be of quite short wave length and that, in consequence, especially when voltages above 600 K V are used, they must constitute a source of great danger not only to the personnel of the operating staff, but also to the entire neighborhood.

To protect against these rays, it appears safest, whenever possible, to house the entire equipment in a separate building, having free walls toward an open space in all directions except the side toward the control room, which would then be connected by a long corridor to the rest of the hospital. It is possible that future improvements in the engineering design of the tube may later contribute toward the elimination of the radiation originating from it. The building-in of an adequate protective ring, in the proximal end of the narrow cylinder, may, for example, cut out most of the back-scattering from the target. On the other hand, by a rebuilding of the electrodes, making use of the electron screen principle, as already done in some of the foreign tubes, one may be able to prevent the diffusion of the electrons and thus the formation of stray radiation from the walls and other portions of the tube. The rays produced by the thermionic tubes become negligible in cases in which smaller individual units are used in cascading the high voltage.

## II ELECTRICAL PROTECTION

The safeguard rules against electrical accidents are, in the main, those provided in the American Recommendations for the installation of all x-ray apparatus. We may add only that it appears wise to supply all doors (those of the treatment cell as well as of the generating room) with circuit

breakers, so that the machine is instantly shut off as soon as any of the doors are opened. In cases in which condensers are used in the transformer units, an automatic dissipator must be supplied, which grounds the high tension end of the tube the moment the machine is stopped. The danger of puncturing the water pipe leading to the target can be entirely disregarded here, for the cooling device is grounded, tap water being used directly. Likewise, the pumping pipe connecting the tube with the pumping system cannot possibly act as a conductor of the high voltage to the control board, for it is connected to the grounded points of the tube.

From the point of view of the patient, the danger of a high tension accident is *nil*. Because the roentgen emission end of the tube, together with the lead cap and the welded lead plates of the treatment cell are connected to deep ground rods by means of several heavy cables, the patient is absolutely protected from the high tension current as well as from all forms of static charges. The grounding of the tube has an additional advantage in that it permits the irradiation from a very short distance without the slightest danger to the patient.

## III GENERAL PROTECTION

We would now like to discuss three protective measures which result from the more general effect of the highly penetrating rays produced by the high voltage apparatus. These are as follows: (a) the advisability of a remote control room, (b) the necessity of a thorough ventilation for the operator, and (c) the necessity of the regulation of the working hours for the personnel.

(a) *Remote Control Room*—It is now an established fact that lead is not absolutely impervious to rays of a very short wave length and, the nearer we approach the gamma rays of radium, the more transparent the proportional lead thicknesses become. Thus we find that at 500 K V,

1 inch of lead, and at 900 K V, 2 inches of lead, appear quite transparent, these figures increasing considerably with still higher voltages. From a practical standpoint, this means that, no matter how large the quantities of lead we use for the protection against the total ray output emanating from the tube, a certain amount of radiation will always reach the operator. This amount becomes larger, the higher the voltage used, and consequently the shorter the wave length of the rays produced. Under these circumstances, it seems that, in a manner similar to radium protection, distance is the only factor which can afford some sort of security and, therefore, the removal of the control room as far as possible from the operating roentgen-ray tube appears necessary. The provision of a periscope for visual control and of microphones and loud speakers for direct verbal communication with the patient, greatly facilitates such an arrangement.

(b) *Thorough Ventilation of Control Room*—The installation of a remote control room serves another good purpose which is directly in connection with the ventilation of the air around the operator. Recent investigators have proven, beyond doubt, that the ionization of the air in roentgen rooms produces no little deleterious effect on the operating personnel. As is known, this air ionization is caused partly by the roentgen rays and partly by the electrical diffusion of the high voltage conductors. By removing the control room as far as possible from both sources, the air ionization around the operator will be reduced considerably. Adding to this an enforced exhaust ventilation, capable of completely changing the air of the control room not less than ten times an hour, as provided for all roentgen rooms in both the International and the American Recommendations, the danger from the air ionization will be reduced to a minimum.

(c) *Regulation of Working Hours for Personnel*—Despite all the above protective measures, it probably will prove necessary, with time, strictly to regulate the

working hours and the "off-time" of the operating personnel. In this respect, the rules will have to be even more strict than those for the protection from radium rays. It was calculated by Failla, for example, that at 700 K V and 5 ma, the radiation emission through 5 mm Cu is equivalent to the gamma-ray emission of from 400 to 600 grams of radium, depending on the criterion of equivalence chosen. By further raising the voltage, this equivalence assumes quite tremendous proportions, so that the distant effect becomes of the greatest importance. That this effect will injure the personnel, with the tube running several hours a day, need not be stressed any further.

#### CONCLUSIONS

The advent of very high voltage installations has created new problems of protection. It is proposed that the solutions of these problems be incorporated in the already existing American and International Recommendations. Especially is it advocated that a new group be created in the American Recommendations, the Class D installation for apparatus running at voltages from 250 K V upward. The protective requirements for the very short wave roentgen rays, generated by such installations, shall then include the following:

- I Protection from roentgen rays
  - (a) Protection from direct radiation,
  - (b) Protection from scattered radiation originating from the treatment cell,
  - (c) Protection from stray radiation originating from the machine plant room
- II Electrical protection
- III General protection
  - (a) Remote control room,
  - (b) Thorough ventilation of control room,
  - (c) Regulation of working hours for personnel

part is generated by the electrons hitting various parts of the roentgen-ray tube, especially if there is a great distance between the cathode end (filament) and target, as in the multisectional tubes, and, finally, a third part is produced by the thermionic rectifiers, in the installations in which such tubes are used for rectification. It is evident that many of these rays must be of quite short wave length and that, in consequence, especially when voltages above 600 K V are used, they must constitute a source of great danger not only to the personnel of the operating staff, but also to the entire neighborhood.

To protect against these rays, it appears safest, whenever possible, to house the entire equipment in a separate building, having free walls toward an open space in all directions except the side toward the control room, which would then be connected by a long corridor to the rest of the hospital. It is possible that future improvements in the engineering design of the tube may later contribute toward the elimination of the radiation originating from it. The building-in of an adequate protective ring, in the proximal end of the narrow cylinder, may, for example, cut out most of the back-scattering from the target. On the other hand, by a rebuilding of the electrodes, making use of the electron screen principle, as already done in some of the foreign tubes, one may be able to prevent the diffusion of the electrons and thus the formation of stray radiation from the walls and other portions of the tube. The rays produced by the thermionic tubes become negligible in cases in which smaller individual units are used in cascading the high voltage.

## II ELECTRICAL PROTECTION

The safeguard rules against electrical accidents are, in the main, those provided in the American Recommendations for the installation of all x-ray apparatus. We may add only that it appears wise to supply all doors (those of the treatment cell as well as of the generating room) with circuit

breakers, so that the machine is instantly shut off as soon as any of the doors are opened. In cases in which condensers are used in the transformer units, an automatic dissipator must be supplied, which grounds the high tension end of the tube the moment the machine is stopped. The danger of puncturing the water pipe leading to the target can be entirely disregarded here, for the cooling device is grounded, tap water being used directly. Likewise, the pumping pipe connecting the tube with the pumping system cannot possibly act as a conductor of the high voltage to the control board, for it is connected to the grounded points of the tube.

From the point of view of the patient, the danger of a high tension accident is nil. Because the roentgen emission end of the tube, together with the lead cap and the welded lead plates of the treatment cell are connected to deep ground rods by means of several heavy cables, the patient is absolutely protected from the high tension current as well as from all forms of static charges. The grounding of the tube has an additional advantage in that it permits the irradiation from a very short distance without the slightest danger to the patient.

## III GENERAL PROTECTION

We would now like to discuss three protective measures which result from the more general effect of the highly penetrating rays produced by the high voltage apparatus. These are as follows: (a) the advisability of a remote control room, (b) the necessity of a thorough ventilation for the operator, and (c) the necessity of the regulation of the working hours for the personnel.

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# CASE REPORTS AND NEW DEVICES

## DYSCHONDROPLASIA

WITH REPORT OF THREE CASES

By M. L. WEINSTEIN, M.D., and  
H. COTELL, M.D., Chicago

Dyschondroplasia is a definite form of cartilaginous dystrophy, usually congenital in origin, and either unilateral or symmetrical in distribution. It is found more often in males than in females. The cases reported show a marked familial and hereditary tendency.

Ollier (1899) was first to describe this condition of bone dystrophy, and reported a case of dyschondroplasia in which there was a unilateral dwarfing of the limbs due to retardation in growth, and an irregular ossification at the diaphyso-epiphyseal junction of the long bones, especially those of the feet and hands. He emphasized the unilateral distribution of this deformity.

Kummer (1900) reported on the same condition and named it "Ollier's disease." He was the first to make a detailed roentgenologic study of this disease and to describe its exact nature. He characterized it as an irregularity and a retardation in the process of ossification of the cartilage, principally in the diaphyseal ends of the long bones. He presumed this cartilaginous tissue to persist abnormally in the form of nodules or masses in the periosteum or deeply in the medulla. These ossify spontaneously and very slowly, to form chondromas. He, therefore, defined this condition as a chondromatosis with a systemic involvement of the skeleton, characterized by the presence of multiple chondromas localized without any definite rule in any of the skeletal segments.

According to Ehrenfried (1915), Virchow described a similar condition and called it "multiple cartilaginous exostosis." Ehrenfried reviewed over 600 cases in the foreign literature and over 75 cases in the American literature, covering a period between 1900 and 1917.

Hale (1930) reviewed 53 cases found in the literature between 1917 and 1930, and described the symmetrical distribution of the bony or cartilaginous tumors, situated mostly at the diaphyseal side of the epiphysis, and, occasionally, on the shaft of the long bones, where there is normally the greatest amount of growth. He did not differentiate between the terminology of "dyschondroplasia" and "multiple cartilaginous exostosis" and used them synonymously.

Keith (1919) described the anatomy and



Fig 1 Case 1 A hard, rough and bony tumor, the size of an orange, protruding from the posteromedial surface of the left leg just below the knee

physiology of Ollier's disease and considered it as an extreme example of diaphyseal aclasis. He included multiple cartilaginous exostosis in the same category of bone dystrophies as dyschondroplasia, and concluded that both showed the identical nature of growth disturbance.

Stocks (1925) reviewed 495 cases of diaphyseal aclasis and 142 cases of multiple enchondromas. He classified and separated the cases of isolated exostosis from those associated with enchondromas, and concluded that Ollier's disease was not a separate entity.

The microscopic sections of the deformed bone showed no structure similar to chondromas, a finding which was confirmed by Johannesson (1923), who found no sign of inflammation or tumor in the sections made from his case. It showed a hyaline network

It becomes evident, from all that has been said in the main part of this article, that because of the intricate manner in which the protection must be embodied in the construction of the apparatus and the general lay-out of the entire plant, the installation of very high voltage roentgen-ray units will probably, at least under present technical conditions, remain limited to the larger institutions

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Fig 5 Case 1 There was a marked bowing of both radii and ulnæ, especially the right, with exostoses at the lower ends of the shafts of the radii. The lower end of the left ulna was incompletely developed and partly fused with that of the corresponding portion of the radius.

at the growing ends, which is no longer restrained by the growing ferrule, provides an opportunity for the outgrowth of multiple cartilaginous tumors. Many of these may remain small and latent until puberty or they may be discovered accidentally during the course of an examination.

The symptoms in the case of dyschondroplasia vary with the extent of the deformity and the degree of disordered growth activity. There may be a stunting in general stature but, more often, there is none, as in our three cases in the same family. The limbs may be definitely stunted and there may be limitation of motion in the joints. The presence of a hard painless swelling attached to the ends of the long bones, to the scapulæ or pelvis may be noted on palpation. An arrest of growth at the lower end of the ulna is commonly seen,

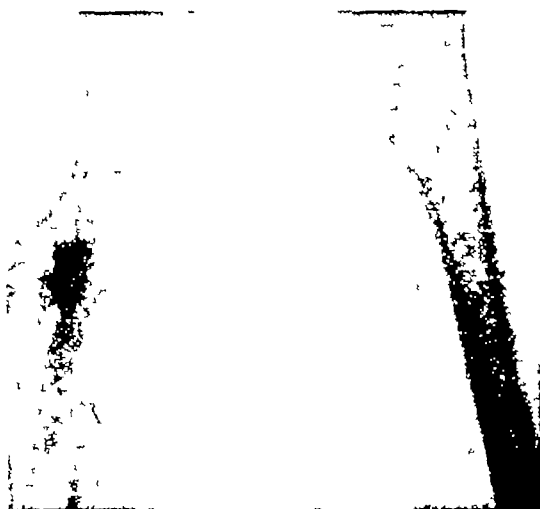


Fig 6 Case 2 A bony exostosis on the posterolateral aspect of the upper third of the right thigh. Roentgenologic examination showed this tumor and also smaller bony exostoses projecting from the diaphyseal region of both femora with rarefaction and widening of the diaphyses.

so that the radius becomes curved and its upper end may be dislocated. The lower ends of the tibia and the fibula usually undergo fusion, a finding which is well demonstrated in one of our cases. Secondary deformities are usually found in older patients and are most marked in the forearm and ankle joints.

A roentgenologic examination usually shows the exostoses and the bowing and fusion of the ends of the bones, mentioned above. In the typical Ollier's disease with a unilateral deformity, one side of the skeletal bones, such as the ilium, femur, and tibia, may be smaller and shorter than those of the opposite side. A characteristic picture is the irregularly expanded diaphyseal mass, with an absence of the cortex. The diaphysis usually shows irregularly shaped areas of rarefaction through which run dense lines, oblique to the long axis of the shaft. Between these lines are clear spaces interposed with small dense nodular shadows having conglomerate appearance (11).

This condition is usually compatible with good health and active life. Occasionally one or more of the multiple tumors increase in size during adolescence and thus may cause discomfort or deformity and interfere with the patient's daily routine, in which case surgical removal of the tumors may become necessary.

There seems to be a general agreement as to the benign character of the lesion. Hume (1929) mentioned the possibility of the appearance of osteogenetic sarcoma in the exostosis, but stated that its occurrence is rare.



Fig 2 Case 1 Smaller protuberances on either side of the lower ends of both femora

rich in cells—extraordinarily numerous but absolutely typical and normal in appearance

Dyschondroplasia is essentially a growth disturbance in which the activity of the cartilaginous and the periosteal elements are involved. The membranous bones such as those of the face, vault, and skull are never affected. The changes occur where the processes of membranous and cartilaginous bone formation come into juxtaposition, which usually occurs at the diaphyseal end of the long bones and at the growing margin of the innominate bone and of the scapula.

John Hunter described the process by which bone grows in length. In the diaphysis, there is first of all a deposit of a cylinder of new bone, which undergoes remodeling before it is incorporated into the shaft. This process is accomplished by the construction of a bony ferrule around the irregular bony cylinder by the periosteum. An arrest of this remodeling process occurs in dyschondroplasia. The presence of a large mass of cartilaginous bone



Fig 3 Case 1 Small hard nodules were palpable over the anterior surfaces of the crest of the right ilium and the right hip joint.



Fig 4 Case 1 Fusion of the lower ends of the tibiae and fibulae

hard nodules were palpable over the anterior surfaces of the crest of the right ilium and the right hip joint (Fig 3). All of these were painless and not tender. Roentgenologic examination of the entire skeleton revealed no involvement of the bones of the skull, vertebrae, or ribs. The bony protuberances as described above were distinctly demonstrated as they projected from the diaphyso-epiphyseal region on the long bones. There were areas of rarefaction, with thinning of the cortex, on both tibiae and fibulae in the region of the origin of the exostoses (Fig 2), also a fusion of the lower ends of the tibiae and fibulae (Fig 4). There was a marked bowing of both radius and ulnae, especially the right, with exostoses at the lower end of the shafts of the radius. The lower end of the left ulna was incompletely developed and partly fused with that of the corresponding portion of the radius (Fig 5). The patient, however, had not been incapacitated at any time in spite of the marked anatomical skeletal deformities. She refused operation and was in good health three years after this examination. She has moved and we are unable to trace her present whereabouts. Since this is a familial disease we advised a roentgenologic examination of her parents and brother, and they furnish the other two cases reported herein.

**Case 2** A white male, 21 years of age, who appeared to be in perfect health and had no complaints. On physical examination no abnormalities were found except that of a bony exostosis on the postero-lateral aspect of the upper third of the right thigh. Roentgenologic examination showed this tumor and also smaller bony exostoses projecting from the diaphyseal region of both femora, with rarefaction and widening of the diaphyses (Fig 6). Small exostoses were found about the upper ends of both tibiae and fibulae, and there was fusion of the lower ends of these long bones (Fig 7).

**Case 3** The father of the above two patients, a fairly well-developed, middle-aged, white male of less than medium height. He has had a swelling on his right leg since his childhood and has paid no attention to it, as it has not disturbed him, moreover, "it ran in his family," since three of his brothers had similar deformities. On physical examination he was shown to be in perfect health. A long bony protuberance was found on the medial surface of the diaphysis of the right tibia (Fig 8). This diaphysis was noticeably expanded and was partly fused to the head of the fibula. There was a marked curvature of the bones of both forearms, with exostoses at the lower ends of both ulnar bones (Fig 9). However, he had no functional



Fig 9 Case 3. There was a marked curvature of the bones of both forearms with exostoses at the lower ends of both ulnar bones.

disturbances in any of his extremities and desired no professional care.

#### CONCLUSION AND SUMMARY

1. Dyschondroplasia is an hereditary and familial disturbance in the growth of cartilaginous bone tissue, most marked at the diaphyso-epiphyseal junction of the long bones.

2. A review of the literature disclosed much discussion, but the majority agreed that dyschondroplasia, or Ollier's disease, is a form of and synonymous with multiple cartilaginous exostosis and diaphyseal aclasis.

3. The characteristic symptoms and roentgenologic findings of this condition are described.

4. Three cases, with complete roentgen studies, are presented.

5. Evidences of malignant transformation or tendency in dyschondroplasia is rare.

6. Surgical interference is indicated in marked deformities and impaired function.

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Fig 7 Case 2 Small exostoses were found about the upper ends of both tibiae and fibulae, and there was fusion of the lower ends of these long bones

Several cases of malignancy have recently been reported by Stout (11), and also, in the Mayo Clinic Reports of 1930 are reports of several recurrences following surgery

#### REPORT OF CASES

Case 1 A well developed white girl, 19 years of age, complained of lumpy masses on her left leg. This leg appeared thicker than the opposite one, and marred her personal appearance, otherwise it did not disturb her. At the age of 8 years, she had noticed a swelling on her left shoulder and one on her right wrist. Two years later another swelling appeared on the calf of her left leg and at this time grew quite large, so that it began to worry her. Her past and developmental histories are negative. On physical examination, she showed normal intelligence, was 5 feet 2 inches in height, and weighed 120 pounds. Her heart and lungs revealed no pathologic findings. Laboratory examination of the urine and



Fig 8 Case 3 A long bony protuberance was found on the medial surface of the diaphysis of the right tibia

blood showed normal findings. Her blood Wassermann and Kahn reactions were negative. There was a hard, rough, and bony tumor, the size of an orange, protruding from the postero-medial surface of the left leg just below the knee. The left leg appeared larger than the right one but was not shorter (Fig 1). There were smaller protuberances on either side of the lower ends of both femora (Fig 2), but larger on the left side. Small

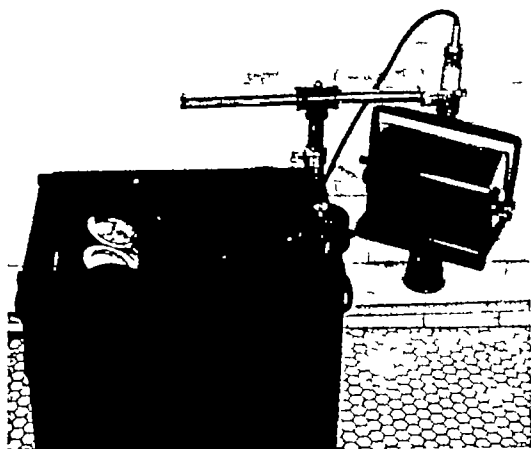


Fig 3 Top, three-fourths view, showing the way in which transformer is set obliquely in the box when in use, to permit the meters to be more easily read

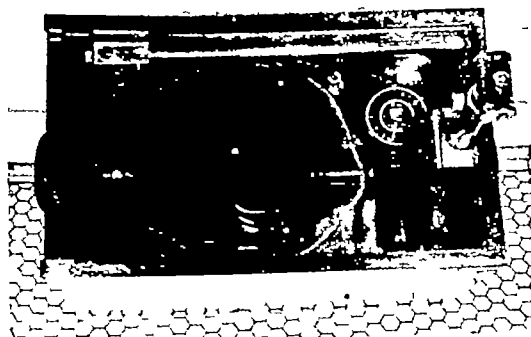


Fig 4 Packed for transportation but with cover removed



Fig 5 Showing cover and shelf which rests on transformer with felt-padded holders to keep tube-head timer etc from vibrating

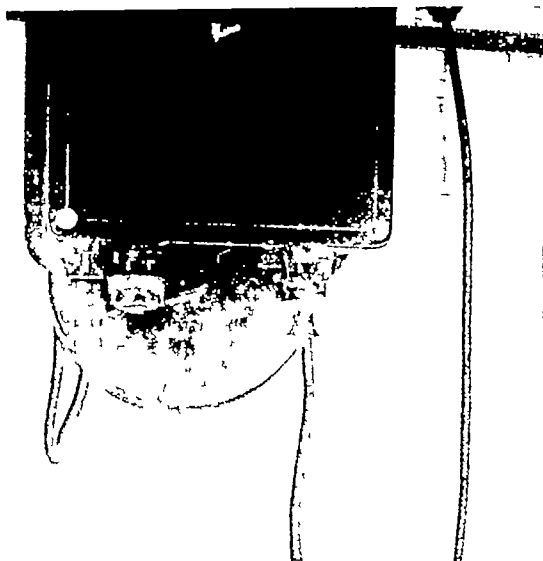


Fig 6 Plugs on bottom of the transformer Right, timer plug, middle, main line plug, left, jack to carry current to tube-head

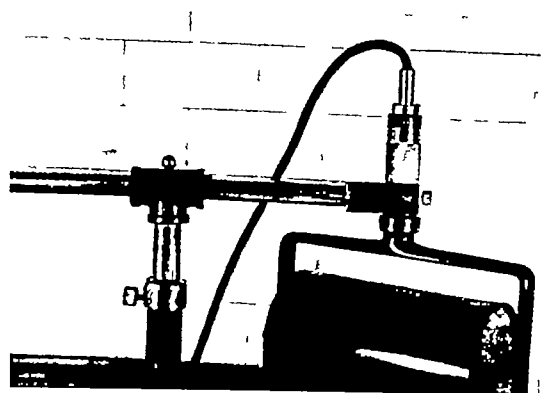


Fig 7 Details of mounting tube-head Stud on head passes through the horizontal arm and screws into especially made plug, one side of line (grounded side) entering through the casing, and the other side through spring-plunger in plug

high tension lines, enables the tube-head to be placed close to the film and, in some measure, makes up for the lack of high power

It is a great source of pleasure to know that I will no longer have to see films being made with high tension lines weaving in and out of an entanglement of orthopedic apparatus

105 Rutledge Ave

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55 E Washington St  
Chicago

vertical part of the stand partly counterbalance the weight of the tube-head. There is no need to ground the machine, when used as a portable.

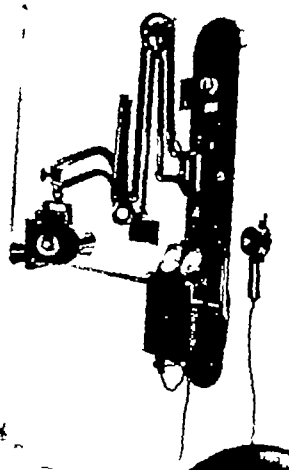


Fig 1 The dental machine

## A NEW IDEA FOR PORTABLE RADIOGRAPHIC MACHINE<sup>1</sup>

By ROBERT B TAFT, M D, B S, F A C R,  
Charleston, S C

Portable radiographic work has never been very popular with most roentgenologists, but in certain cases it makes the radiographic examination accessible to the patient who would otherwise have to do without it. Lightness, simplicity, and ease of operation contribute greatly to the success of the work.

A dental machine, which is found in many of the better equipped radiologic departments, with certain adaptations, makes an ideal low-powered portable. I have attempted to show in this paper that these adaptations can be easily arranged without, in any way, distracting from the usefulness of the machine in its intended use. While I would not recommend it for general radiography, still, when operated by a skilled technician, it is quite capable of making good films of any parts of the body except the abdomen.<sup>2</sup>

First of all, the lead wires must be connected to the plugs as shown in Figure 6, and if three different kinds of plugs are used, there is no possibility of the wrong connections being made when the machine is set up. The method of attaching the tube-head to the new stand is shown in Figure 7. Heavy springs in the

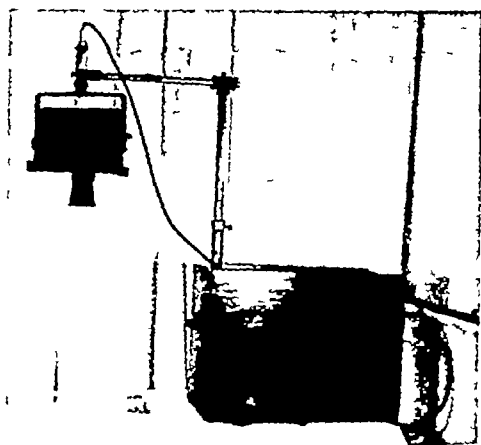


Fig 2 Machine arranged as a self-contained portable

able, unless it comes in contact with the patient, and only then as a precautionary measure, as there is ordinarily no potential on it.

Only one difficulty was experienced in this conversion and that came about from the fact that the cover of the timer was grounded to one side of the circuit. This, of course, gave a half-and-half chance of connecting one side of the 110-volt line to the hand of the technician. To eliminate this unpleasant feature, it is necessary to remove this connection from the inside of the timer. The small focal spot of this tube, along with the total absence of the

<sup>1</sup>Read before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1, 1932

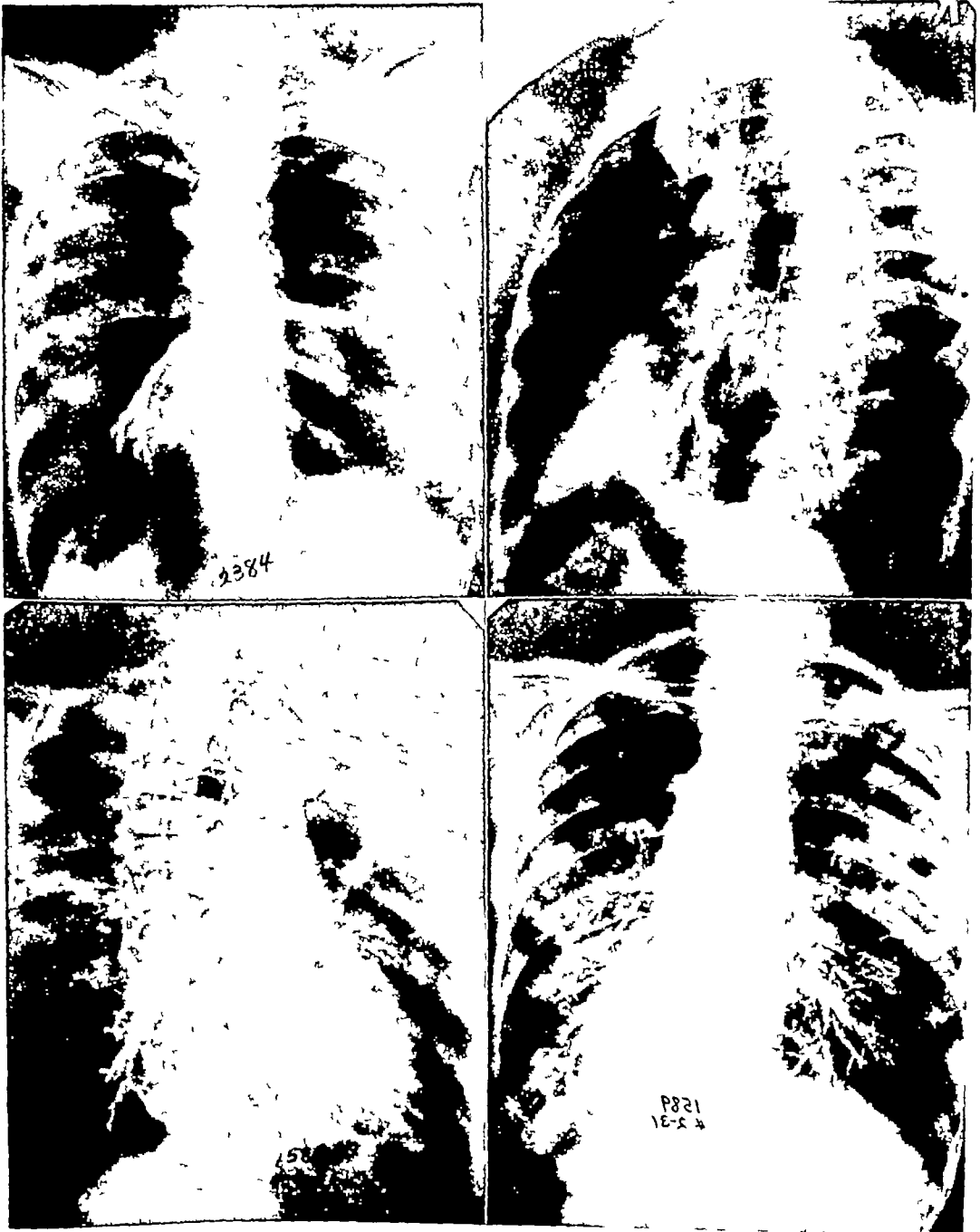
<sup>2</sup>The illustrations show the method of arranging the carrying-case with the tube stand attached. However, no exact dimensions or instructions are given.

was not visualized below the level of the seventh dorsal vertebra. No barium entered the stomach.

Roentgenographic examination of the chest revealed extensive involvement of both lungs by infiltration, and areas of consolidation.

The bronchioles of the middle and lower lobes were visualized by the barium from the fistula with the esophagus (Figs 3 and 4).

*Diagnosis*—Carcinoma of the esophagus, with rupture into the bronchi, pulmonary abscess.



Figs 1 and 2 (above) Case 1 Cancer of esophagus  
Figs 3 and 4 (below) Case 2 Cancer of esophagus, with fistula into bronchus

# MALIGNANCY OF THE ESOPHAGUS, WITH BRONCHIAL FISTULA

## CASE REPORTS

By WILLIAM E ALLEN, JR., M.D., St. Louis

From the Departments of Radiology, City Hospital  
No. 2 and St. Mary's Infirmary

Erosion of the trachea or a bronchus, with the formation of a fistulous tract, is not common, however, it occurred in the two cases herein reported. The picture is characteristic and, once seen, can hardly be misinterpreted. The ingested barium mixture (barium mixture is spoken of because these fistulae were discovered during the course of a routine gastro-intestinal examination) is seen to leave the esophagus at the point of communication and to enter the trachea or a bronchus. A severe dyspneic and coughing attack follows immediately. The barium is seen in the bronchi both fluoroscopically and on the plates. Of course, in the presence of a known esophagobronchial fistula, the condition is best studied by means of iodized oil.

Case 1. Colored male, aged 49, was admitted on Sept. 25, 1931, complaining of inability to swallow without vomiting. The family history was negative. He admitted pleurisy, syphilis, and several attacks of *neisserian* infection, having received intensive treatment for the latter two conditions. Although the patient attributed his present illness to his having swallowed a fish bone four weeks prior to his admission, he admitted having been treated at another hospital for six months in 1929 and again for several weeks during 1931 for pains in the epigastrium which migrated to the right hypochondrium. For the past few months he had gradually lost weight and had suffered with anorexia and gastric upsets. Violent attacks of emesis accompanied by expectoration of blood, pus, and mucus had followed every attempt to swallow, even water, for six days before he sought hospitalization.

Physical examination revealed a markedly emaciated adult male lying uncomfortably in left lateral decubitus. There was slight anemia of the mucous membrane. Vocal fremitus was increased over the lower chest. The breath sounds were harshly bronchial in character and whispering pectoriloquy was heard over the left lower lobe.

There were no tender areas or palpable masses in the abdomen, but there was an exquisitely tender spot in the back, at the level of the twelfth thoracic vertebra. The cervical, axillary, inguinal, and epitrochlear lymph nodes were enlarged. There was extreme clubbing of all fingers.

The Wassermann reaction was 2+, blood pressure 128/92, red blood count, 3,200,000, white blood count, 6,100, coagulation time, 45 minutes, hemoglobin, 60 per cent, urinalysis disclosed nothing of significance.

A roentgenogram of the chest revealed a marked increase in the peribronchial markings of both lungs, extending well into the periphery and assuming somewhat of a honey-comb formation, a condition which appeared highly suggestive of bronchiectasis. A barium meal was administered and the patient examined under the fluoroscope. There was complete obstruction of the esophagus at the level of the eighth dorsal vertebra, a fistula extended between the esophagus and the left bronchus, and that portion of the esophagus immediately above the obstruction was serrated and of a conical shape (Figs. 1 and 2).

*Diagnosis*—Carcinoma of the esophagus, with esophagobronchial fistula.

After an attempt to strengthen the patient by means of intravenous, subcutaneous, and rectal nourishment, a gastrostomy was performed in an effort to prolong life. The patient survived the operation by only 12 hours. Unfortunately an autopsy was not obtained.

Case 2. Colored male, aged 84, was admitted on March 31, 1931, complaining of persistent vomiting and gastric pain. There was nothing of significance in his past or family history. For the previous two years, the patient had complained of gastric disturbances and loss of weight. One month before his admission, he began to suffer with severe attacks of emesis and gastric pain, the attacks occurring about two hours after each meal. For the past week these attacks had been continuous and the vomitus contained large amounts of blood.

Physical examination revealed a very sick, markedly emaciated, adult male, lying in weak, dorsal decubitus. His tongue was heavily coated and his breath foul. Fine crepitant râles over both lungs and a friction rub over the left base were elicited. The heart was slightly enlarged to the left. No distention or palpable masses were noted in the abdomen, but there was marked rigidity and tenderness in the epigastrium. The back and extremities were negative except for the previously mentioned emaciation.

The blood pressure was 150/80, white blood count, 10,500, hemoglobin, 70 per cent, no abnormal urinary findings.

Roentgenographic and roentgenoscopic examination of the gastro-intestinal tract revealed a fistula of the esophagus with the bronchi, through which the barium entered the middle and lower lobes. The esophagus

## CONCLUSIONS

- 1 A foreign body which does not completely obstruct a bronchus may be present for a long time without producing symptoms
- 2 A foreign body can be coughed up by the patient and re-inhaled
- 3 Foreign bodies can change their position in the lungs

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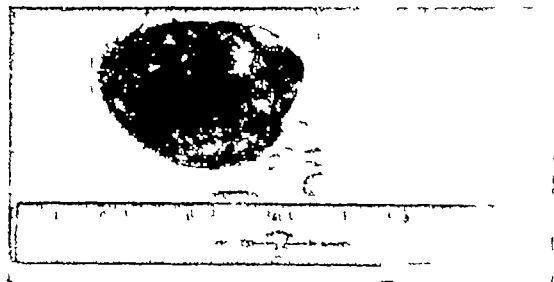


Fig 1 Specimen, showing relative size

CAVERNOUS HEMANGIOMA OF THE LEG<sup>1</sup>

By WILLIAM H TELLER, M D, LEON SOLIS-COHEN, M D, and SAMUEL LEVINE, M D,  
*Philadelphia*

The reason for reporting this case is its relative infrequency and the puzzling roentgenologic aspects as to whether the tumor mass, as observed on the film, sprang from the periosteal bone layer or secondarily involved bone.

The patient was a white female, aged 63 years. To use her own words, the growth began 22 years ago, as a "small hole in the left leg, which alternately would heal over and break down again." Ten years ago it began to grow and amputation of the limb was advised, but refused. It has grown steadily larger, and the leg is painful when the patient is walking. The tumor bleeds readily and on one occasion there was a distinct hemorrhage. Otherwise, the previous history of the patient has no bearing. Spinal and blood Wassermanns are negative. Complete blood count is normal.

There is a large tumor mass (Figs 1 and 2), ulcerating and cirroid in type, springing from the soft tissue of the left leg on the anterior aspect. The tibialis anterior is the muscle involved.

**Radiographic Appearance**—There is a large nodular, cirroid oval tumor mass in the anterior aspect of the lower third of the left leg, which extends posteriorly into the interosseous space. There are two or three small bone spicules lying at right-angles to the shaft of the tibia and penetrating the growth. The periosteum is proliferated and elevated along the anterior aspect of the tibia, and the cortex is thickened. There is no invasion of the medullary canal nor any breaking down of the cortex of the tibia. There is sclerosis of the cortex in the region of the head of the tibia along the inner aspect of the head and neck. The fibula shows definite periosteal reaction and proliferation along both borders of the

shaft. There is decalcification of the shaft of the fibula. In the neck of the fibula is a small circular area of bone rarefaction, with a calcific border suggesting an old healed cyst.

We thought that a tumor arising from the bone was definitely excluded and that a periosteal origin of the tumor, a simple fibroma, or one undergoing sarcomatous change, was the most likely diagnosis. The appearance of the mass definitely excluded syphilis and osteogenic sarcoma. As in this case, the diagnosis is seldom made before operation.

**Operation**—Using a tourniquet above the tumor, the entire growth was removed by Dr. Teller. Moderate hemorrhage was encountered. The underlying periosteum was removed with the growth.

**Macroscopy**—The specimen consists of a segment of tissue measuring  $9.5 \times 7.5 \times 3$  centimeters. Superficially it is a cauliflower growth—an ulcerating, fungating, irregularly shaped mass having an elliptical edge. On cross-section several hemorrhagic cyst-like spaces are noted, the edges of these areas being indurated and necrotic. Grossly, the tumor was an integral part of the tibialis anterior muscle, being attached to the periosteum of the tibia. A small spicule of bone projected from the tibia into the substance of the growth. The tumor is permeated throughout by variously shaped and sized cavities filled with either hemorrhagic or slate colored semi-gelatinous material. A portion of the periosteum and the underlying bone is also present, the former considerably hypertrophied and thickened. No bone involvement by the tumor is seen.

**Microscopy**—A section of tissue is lined by squamous stratified epithelium, sharply outlined. The subepithelial layers show areas composed of numerous capillaries. Some of the spaces are sponge-like in appearance, while other vascular spaces are sacculated, and some of the blood channels intercommunicate. Considerable necrosis is present, and secondary infection. Many polymorphonuclears and plasmacytes are noted, together with old hemorrhagic extravasation and blood

<sup>1</sup> Reported from the service of William H. Teller, M.D., Jewish Hospital Philadelphia

The patient rapidly grew weaker and died on the fourth day after admission.

At autopsy the lungs were found to be covered with a heavy black deposit and, upon section, exhibited the previously aspirated barium sulphate. The bronchial glands were enlarged to the size of a hickory nut and showed a dark bluish color upon section. Just at the bifurcation of the trachea, the esophagus consisted of a hard, nodular, partly eroded mass about the size of the fist. On splitting this mass, a false tract leading into the left bronchial tube was revealed. The esophagus for about two inches, extending between the area of involvement and the cardiac end of the stomach, was free of pathology. The stomach was dilated and the walls were very thin. At the cardiac end, on the posterior wall, there was a cup-shaped depression, the size of a quarter-dollar, with elevated borders. The tissues around the depression were infiltrated with nodular growths. After microscopic study of a section taken from the involved area of the esophagus and trachea, the pathologist, Dr C W Scherry, reported a small round-cell sarcoma.

### AN UNUSUAL CASE OF FOREIGN BODY IN THE BRONCHI

By H E KIMBLE, M D, *Chicago*

A white boy, 7 years of age, was brought into the office, complaining of pain in his abdomen.

The father stated that four weeks previously the child choked on a whistle. His mother became frightened and pushed her finger down the child's throat, after which he appeared to be all right. No more was thought about the whistle until the child began to complain of cramps in his lower abdomen. During all this time the boy had been well with the exception of an occasional harsh dry cough. Fear that the whistle caused the child's distress impelled the parent to bring him in for examination.

No definite findings were elicited on physical examination.

Fluoroscopic examination of the abdomen was negative, in the chest, however, a foreign body was observed in the superior branch of the right bronchus (Fig 1).

Bronchoscopic examination was advised and made later in the day. No foreign body was found, though, on fluoroscopic examination, it was seen in the same position. The following morning an x-ray plate was made of the patient's chest, revealing the foreign body in the inferior branch of the left main bronchus (Fig 2). The hospital nurse reported that the patient had had one or two severe coughing spells during the night.

On subsequent bronchoscopic examination the foreign body was easily located but was removed only after repeated attempts. It proved to be a tin reed about 0.8 cm X 2 cm, out of a toy whistle. The child made an uneventful recovery.



Fig 1 Location of foreign body at time of admission of patient to hospital

Fig 2 Location of foreign body at time of its removal

## CONCLUSIONS

1 A foreign body which does not completely obstruct a bronchus may be present for a long time without producing symptoms

2 A foreign body can be coughed up by the patient and re-inhaled

3 Foreign bodies can change their position in the lungs

7854 S Ashland Ave

CAVERNOUS HEMANGIOMA OF THE LEG<sup>1</sup>

By WILLIAM H. TELLER, M.D., LEON SOLIS-COHEN, M.D., and SAMUEL LEVINE, M.D.,  
*Philadelphia*

The reason for reporting this case is its relative infrequency and the puzzling roentgenologic aspects as to whether the tumor mass, as observed on the film, sprang from the periosteal bone layer or secondarily involved bone.

The patient was a white female, aged 63 years. To use her own words, the growth began 22 years ago, as a "small hole in the left leg, which alternately would heal over and break down again." Ten years ago it began to grow and amputation of the limb was advised, but refused. It has grown steadily larger, and the leg is painful when the patient is walking. The tumor bleeds readily and on one occasion there was a distinct hemorrhage. Otherwise, the previous history of the patient has no bearing. Spinal and blood Wassermanns are negative. Complete blood count is normal.

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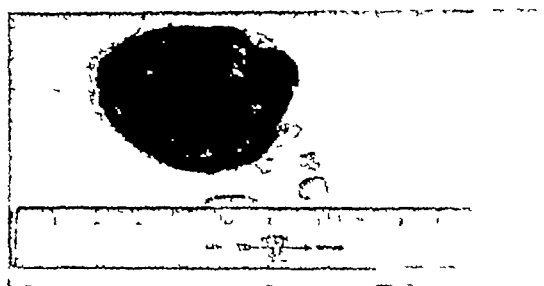


Fig 1 Specimen, showing relative size

shaft. There is decalcification of the shaft of the fibula. In the neck of the fibula is a small circular area of bone rarefaction, with a calcific border suggesting an old healed cyst.

We thought that a tumor arising from the bone was definitely excluded and that a periosteal origin of the tumor, a simple fibroma, or one undergoing sarcomatous change, was the most likely diagnosis. The appearance of the mass definitely excluded syphilis and osteogenic sarcoma. As in this case, the diagnosis is seldom made before operation.

**Operation**—Using a tourniquet above the tumor, the entire growth was removed by Dr. Teller. Moderate hemorrhage was encountered. The underlying periosteum was removed with the growth.

**Macroscopy**—The specimen consists of a segment of tissue measuring  $9.5 \times 7.5 \times 3$  centimeters. Superficially it is a cauliflower growth—an ulcerating, fungating, irregularly shaped mass having an elliptical edge. On cross-section several hemorrhagic cyst-like spaces are noted, the edges of these areas being indurated and necrotic. Grossly, the tumor was an integral part of the tibialis anterior muscle, being attached to the periosteum of the tibia. A small spicule of bone projected from the tibia into the substance of the growth. The tumor is permeated throughout by variously shaped and sized cavities filled with either hemorrhagic or slate colored semi-gelatinous material. A portion of the periosteum and the underlying bone is also present, the former considerably hypertrophied and thickened. No bone involvement by the tumor is seen.

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<sup>1</sup> Reported from the service of William H. Teller, M.D., Jewish Hospital Philadelphia





Fig 2 Gross appearance of the lesion

pigment. There is considerable fibrosis noted throughout. Some sections of the tumor present rapid cellular proliferation, some of the individual cells being spindle-shaped, though they do not show hyperchromatism. Certain fields show widespread areas of muscle undergoing Zenker's degeneration. In longitudinal section, the muscle fibers have lost their striations, while in cross-section, nothing is left of muscle fibers but the sarcolemma and the nuclei, so that they simulate giant cells. Numerous cavernous spaces and capillaries have worked their way into the muscle, some

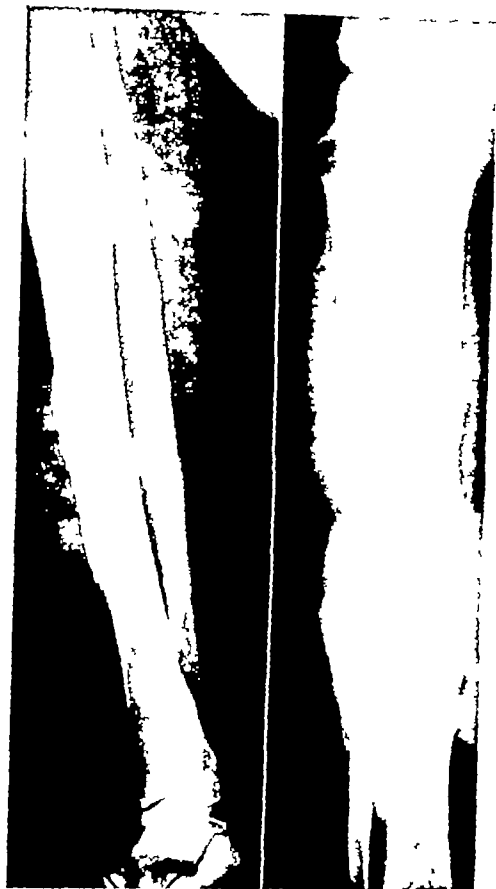


Fig 3 Roentgenograms of cavernous hemangioma of muscle. Observe soft-tumor shadow, spicule of bony attachment, and perosteal reaction of tibia and fibula.

of the latter showing proliferative change, and clusters of foam cells are occasionally noted.

*Discussion*—In a recent article H. R. Jenkins and P. A. Delaney reviewed 255 cases of benign angiomatous tumors of muscle, and reported one additional case. We are reporting the two hundred fifty-seventh case in the literature because of some unusual and uncommon clinical and radiographic features. No history of trauma was elicited in this case. It began in the fourth decade although the patient is now in the sixth. In addition to various theories of origin, all of which are speculative or theoretical, Jenkins and Delaney feel that a congenital factor plays an important etiologic rôle.

There are three types of hemangioma: a diffuse type, a partially circumscribed type, and a circumscribed type. Our case was diffuse, adherent to the periosteum, the overlying

skin was necrotic, and the whole mass had a foul odor

Out of the 256 previously reported cases, in 39 a leg was involved. The size varies from that of a bean to that of a child's head. Ulcerated and necrotic skin is rare, over 50 per cent showing normal skin and the rest are variously discolored.<sup>2</sup>

*Diagnostic Point*—Of these tumors, 79 per cent appear during the first twenty years and 94 per cent during the first thirty years.

Forty-two per cent of them are located in the lower extremities.

The tumor mass is usually painless at first, but pain occurs in about 58 per cent during the course of the disease.

Some functional impairment or deformity occurs in about a fourth of the cases.

When blood is aspirated in an exploratory puncture of the tumor, it is of considerable importance in establishing a correct diagnosis. X-ray examination may help in making the diagnosis, particularly if phleboliths are found.

With regard to the x-ray findings, it is noteworthy of comment that in two cases only has a soft tissue shadow been cast by the tumor. Because of the size and the suspicion of malignant degeneration, irradiation therapy (1,800 r) was given to the tumor site without any change being observable.

*Differential Diagnosis*—The most common pre-operative diagnoses have been lipoma, neuroma, neurofibroma or fibroma, sarcoma, and dermoid cyst. Our diagnosis was fibroma or fibroma undergoing sarcomatous degeneration.

*Prognosis*—No report of mortality following or previous to operation has been found. Recurrence was reported 15 times, mostly after incomplete excision.

#### SUMMARY

A case of benign angiomatous tumor of the leg is reported, with a roentgen summary. The etiology of the type of tumor is still unknown, though observers believe that both a congenital and a traumatic factor are of importance. The correct diagnosis is seldom made before operation, but phleboliths on the x-ray film are significant. Other diagnostic signs are periosteal reaction in the bones of the part in which the tumor arises, demineralization of the bones, increase or decrease of surface temperature, evidence of interference of circulation, presence of a slow-growing mass involving muscle, and aspiration of blood from the tumor.

<sup>2</sup> For a complete analysis of cases reported the reader is referred to *Surgery, Gynecology and Obstetrics*, October, 1932.

We are dealing here with a cavernous muscle hemangioma. In spite of the chronicity of the tumor, we are inclined to believe that this neoplasm will recur locally or show evidence of metastasis in the future. This conclusion is drawn from the fact that cellular proliferation is very active.

#### IODISM FOLLOWING ORAL ADMINISTRATION OF GALL-BLADDER DYES

By KENNETH S. DAVIS, M.D., and S. GORDON ROSS, M.D., Los Angeles, Calif.

From the X-ray Laboratory St. Vincent's Hospital

During the earlier period of the development of cholecystography, reactions were frequent and occasionally of an alarming nature. However, since the introduction of tetraiodophenolphthalein and especially phenoltetraiodophthalein it is seldom that one encounters a reaction of serious consequence.

Graham, Cole, Copher, and Moore report that in 85 per cent of their cases there is little or no reaction to the intravenous administration of gall-bladder dyes. Mild reactions reported in the literature following intravenous gall-bladder dyes consist of vertigo, headache, backache, nausea, weakness, and urticaria. Among the more severe reactions are included the following: severe nausea, vomiting, chills, circulatory depression, fever, and severe abdominal cramps. Following the oral administration, the usual reactions encountered are nausea, vomiting, diarrhea, and abdominal cramps. The factors influencing reaction are first, the freshness of the preparation, second, the susceptibility of the patient, and third, the amount of the dye substance given.

The contra-indications to cholecystography generally mentioned in the literature are cardiac decompensation and jaundice, especially if the latter is due to acute liver infection or to common duct obstruction. It has also been observed that patients with an abnormally high or low blood pressure are more susceptible to reaction than patients with blood pressure near the normal limits. Graham and Cole state that threatened uremia is a contra-indication to cholecystography. In a survey of the literature we were unable to find any recorded cases of iodism following the use of gall-bladder dyes.

#### CASE REPORT

A male patient, 57 years of age, was referred to the x-ray laboratory at St. Vincent's Hospital on Oct. 22, 1932, for a gall-bladder dye study. He had been complaining for the past



Fig 2 Gross appearance of the lesion

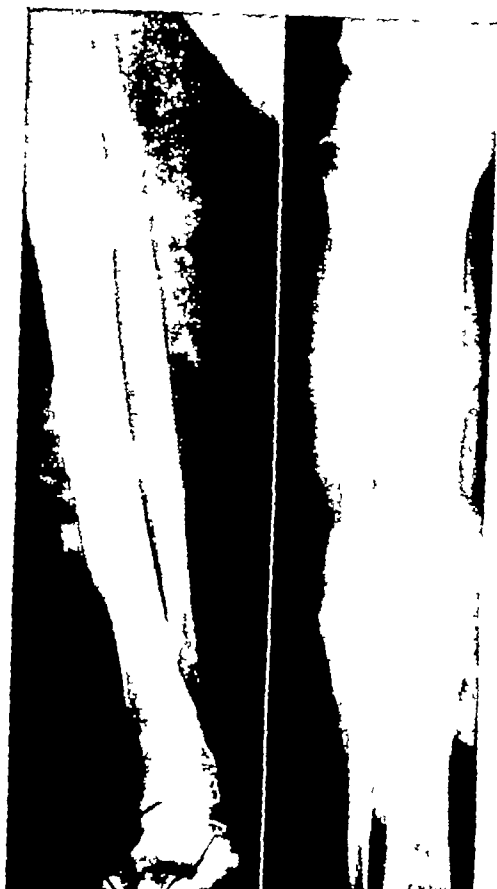


Fig 3 Roentgenograms of cavernous hemangioma of muscle. Observe soft-tumor shadow, spicule of bony attachment, and periosteal reaction of tibia and fibula

pigment. There is considerable fibrosis noted throughout. Some sections of the tumor present rapid cellular proliferation, some of the individual cells being spindle-shaped, though they do not show hyperchromatism. Certain fields show widespread areas of muscle undergoing Zenker's degeneration. In longitudinal section, the muscle fibers have lost their striations, while in cross-section, nothing is left of muscle fibers but the sarcolemma and the nuclei, so that they simulate giant cells. Numerous cavernous spaces and capillaries have worked their way into the muscle, some

of the latter showing proliferative change, and clusters of foam cells are occasionally noted.

**Discussion**—In a recent article H. R. Jenkins and P. A. Delaney reviewed 255 cases of benign angiomatous tumors of muscle, and reported one additional case. We are reporting the two hundred fifty-seventh case in the literature because of some unusual and uncommon clinical and radiographic features. No history of trauma was elicited in this case. It began in the fourth decade although the patient is now in the sixth. In addition to various theories of origin, all of which are speculative or theoretical, Jenkins and Delaney feel that a congenital factor plays an important etiologic rôle.

There are three types of hemangioma: a diffuse type, a partially circumscribed type, and a circumscribed type. Our case was diffuse, adherent to the periosteum, the overlying

herpes zoster, which cleared up as far as the eruption was concerned but at the time of examination he had a feeling of tightness of the skin, could not raise the eyebrow, and had been having constant neuralgia that was not

again given 148 r, which relieved the pain and checked the eruption. However, in ten days he returned with pain and herpes showing on the buccal membrane. Again the pain and eruption subsided, but he was left with a

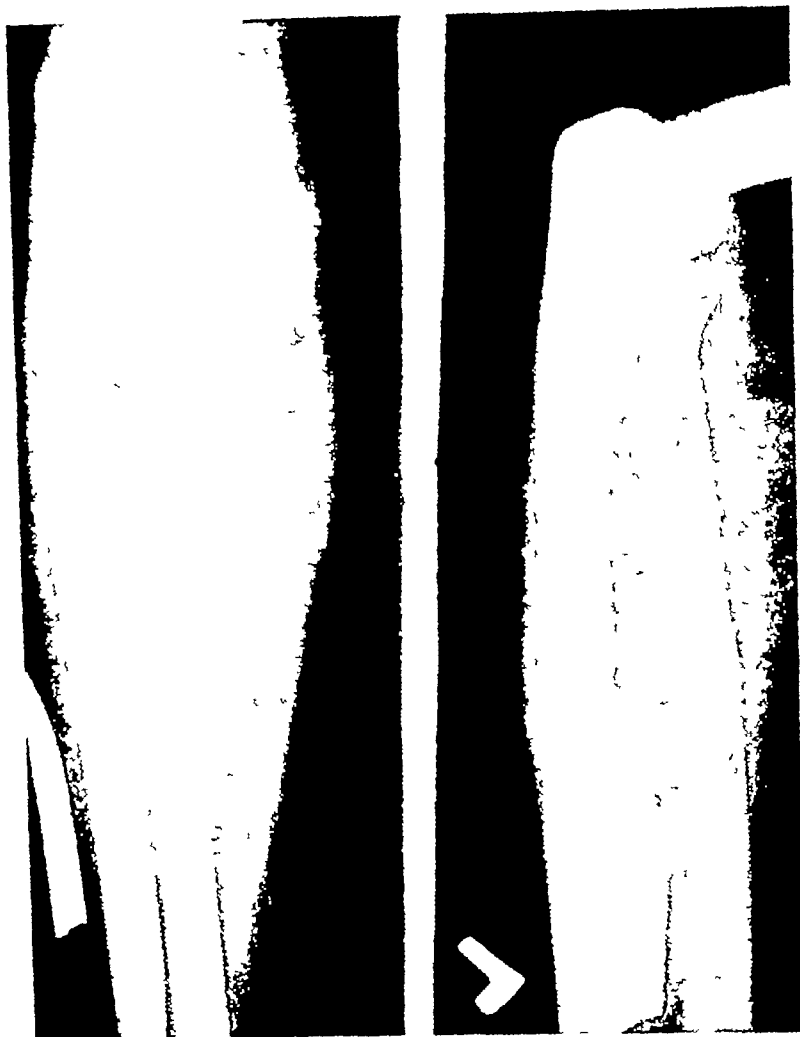


Fig 1 Roentgenogram showing forearm with foreign body (knife blade)  
(See page 374)

relieved by analgesics. He was given 148 r over the Gasserian ganglion at intervals of ten days, and after the third dose had completely recovered.

**Case 2** This most interesting case was that of a man, aged 70, who was referred on account of excruciating pain over the distribution of the fifth cranial nerve, with herpes zoster in front of and below the ear. He was given 148 r, following which therapy he was comfortable for ten days and the eruption disappeared. There was a recurrence of pain, with herpes in the aural canal and on the drum. He was

paralysis of the left side of the face and an internal squint. These conditions disappeared in a few weeks and by the seventieth day recovery was complete.

The ages of the cases in the series reported were from 5 to 82 years. Males constituted 90 per cent. Half of the cases were due to inflammation of the thoracic posterior root ganglion, 10 per cent were cervical, 13 per cent lumbar, 10 per cent sciatic, and 17 per cent cranial. Onset was quite evenly distributed throughout the year. In treating, 90 per cent received only one dose of x-rays,

five years of constant stomach trouble which came on particularly after taking fried foods, fats, rich food, onion, cabbage, etc. His chief complaint was distention and gas, there was very little belching or nausea, and no vomiting. Bowels were constipated, stools were unusually light and at times clay-colored. A previous gastro-intestinal examination had failed to reveal evidence of intrinsic organic involvement of the gastro-intestinal tract. Patient was not jaundiced. He was given a prescription for a one-ounce bottle of a well-known brand of gall-bladder dye emulsion. Following directions, he had a fat-free evening meal and at 7 P.M. took the contents of the bottle in four ounces of Welch's Grape Juice. Three and one-half hours after taking the emulsion, the patient became very apprehensive when he experienced difficulty in breathing and pain in the back of the head. He developed a burning sensation in the mouth and throat as though he had swallowed red pepper. The tongue was so enlarged that it filled the mouth, making speech and swallowing impossible. The lips were swollen and the alveolar processes were ten times their normal size. The submaxillary glands were swollen to the size of a small hen's egg and, by 3 A.M., were very tender. The parotids were enlarged, resembling a bad case of mumps. There was marked puffiness around the eyes and severe occipital headache. Salivation was marked and very annoying, due to the loss of function of the tongue and lips. The salivary glands remained swollen for several days. Subsequent examination revealed no constitutional condition or metabolic deficiency to account for this reaction. The blood and urine were normal. Iodism in this case was manifest only in the salivary glands and buccal contents. There was no skin manifestation seen during the illness.

Correspondence with the Company manufacturing the dye shows that it was made on Sept. 14, 1931, over one year prior to its use. The patient stated that he had had a gall-bladder dye study made three years before, without marked reaction.

*Comment*—The most commonly reported symptoms of iodism are the skin eruptions and varying degrees of catarrhal involvement in the respiratory tract, with severe gastro-intestinal disturbances as a frequent accompaniment. Solutions and compounds containing large percentages of iodine are used extensively in therapeutics or as opaque substances for radiography of the cerebral and spinal spaces, gall bladder, urinary tract, uterus and tubes, sinuses, and bronchi. Such preparations are potential sources of iodism.

Firth reports a case of iodism following the

introduction of 30 c.c. of chlorodized peanut oil (a small portion of which was swallowed) into his bronchi. His symptoms were strikingly similar to those observed in our case. Iodism following the use of gall-bladder dye may be experienced unless great care is observed in its administration and a strictly fresh preparation used. Had our patient been given the dye substance intravenously, the reaction would undoubtedly have been more severe and might have resulted fatally.

## SIXTY-TWO CASES OF HERPES ZOSTER SUCCESSFULLY TREATED WITH X-RAYS<sup>1</sup>

By JOHN M. KEICHLINE, M.D. *Huntingdon, Pennsylvania*

It is now safe to regard the peculiar eruption of herpes zoster as being in every case the trophic expression of inflammation of the corresponding ganglion of the posterior root, whether spinal or cranial. Etiology of the idiopathic form is not known, but Teague and Goodpasture's hypothesis of the *modus operandi* is as good as any, and the toxic, secondary, and infectious causes as seen in gout, adjacent organic disease, and meningitis are known to all clinicians.

Herpes zoster has been treated with x-rays as a dermatitis, with about the same degree of success as attends upon other therapy—superficial and symptomatic treatment may ameliorate but will not abort or shorten the course of an inflammation of a posterior root ganglion.

Among the first cases treated were members of our hospital staff. Our internist sought relief from severe pain in his right chest and upon examination, we found he had the first bouquet of herpes zoster over the sensory fibers. He was given 148 r through 3 mm. aluminum at a 30-cm. distance over the eruption and to the corresponding root ganglion. In a few hours the pain was relieved and the next morning he reported that only a slight trace of the original eruption could be seen and no new bouquets had formed. All patients seen in the early stage responded in like manner, except 8 per cent, who were given a second dose the following day for pain.

Of the cases seen, 2 per cent were post-paralytic. The following cases will illustrate the results.

Case 1. Male, aged 52, was referred on account of pain in the left forehead and side of the face. Four weeks previously he had had

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## THE EVOLUTION OF THE ROENTGEN CRITERIA IN ADULT PULMONARY TUBERCULOSIS

From time to time, in our onward march of progress in roentgenology, it behooves us to stop to consider briefly the steps we have taken to arrive at our present state of knowledge. Some of these steps are due to improvements in mechanical equipment and in technic, but many are the result of painstaking experimental and clinical studies by the early workers. In the early day of roentgenology, observations were made in pulmonary tuberculosis despite the technical difficulties involved.

In the earliest reports on chest examinations the fluoroscope occupied the preëminent position, probably because of the technical difficulty in producing a diagnostic plate. On Oct. 1, 1896, in the "Boston Medical and Surgical Journal," Francis H. Williams<sup>1</sup> reported as follows: "I have examined about forty cases of pulmonary tuberculosis, and find not only that the fluoroscope is of value in determining the extent of the disease, but also sometimes reveals its location where and when it would otherwise have been unsuspected." In 1903 the same author states that, "While the x-ray photographs show clearly that the lungs are denser than normal when the disease has passed the very earliest stage, thus far I have been able to detect an abnormal condition of the lungs in early tuberculosis better by means of the fluorescent screen than by means of the photograph. The screen is a readier and more certain test."

The principal fluoroscopic findings which he recorded were a dark shadow due to increased density, and a restriction of the diaphragm on the affected side, usually in the lower part of its excursion.

The radiographic part of the examination was facilitated by the work of Hulst,<sup>2</sup> who, in 1902, produced the first lung roentgenograms made in America in one second without the aid of intensifying screens. As the technical difficulties in radiography were gradually

solved the fluoroscope lost its preëminent position and as early as 1906 Pfahler<sup>3</sup> warned of the danger of fluoroscopy. He also felt that it was inaccurate and not necessary.

From this time on, the search for positive radiographic evidence of tuberculosis occupied the center of the stage. Much was written and many roentgen signs were described, but it remained for Cole<sup>4</sup> to insist upon the visualization of the tubercle, or conglomerate tubercle, as the earliest positive manifestation of pulmonary tuberculosis. He states that these earliest changes are the intermediate sized tubercles, the smallest ones that are clearly discernible to the naked eye on cross-section of the lung. "It is on these tubercles that the positive diagnosis of incipient pulmonary tuberculosis by the x-rays depends."

Dunham,<sup>5</sup> in 1916, described fan-shaped densities in the lung near the pleura. He stated that they were due to masses of tubercles and took their shape from the anatomy of the portion of the lung involved and not from the shape of the tubercles. This is essentially an area of lobular pneumonia due to an early infection of one or more lobules. Exudation accompanying the infection produces most of the hazy shadow seen in early lesions. The work of Cole and Dunham has been provocative of much critical discussion, but their work remains to-day as two of the guide posts that direct our course in the diagnosis of pulmonary tuberculosis.

The roentgenologic diagnosis of the adult form of pulmonary tuberculosis rests upon the visualization of conglomerate tubercles, the accompanying exudate, fibrosis, and calcification, depending upon the stage and activity of the lesion at the time seen. It may not be possible to visualize the conglomerate tubercle because of surrounding exudate, but when seen in the subapical area it is a very positive aid in diagnosis. In a sensitized person, exudation about the focal lesion may be the earliest roent-

<sup>1</sup> F. H. Williams. *The Roentgen Rays in Medicine and Surgery*. Third edition. Macmillan, New York, 1903.

<sup>2</sup> H. Hulst. *Trans. Am. Roent. Ray Soc.*, 1903.

<sup>3</sup> G. E. Pfahler. *Jour. Am. Med. Assn.*, XLVI, 23.

<sup>4</sup> L. G. Cole. *Am. Jour. Med. Sci.*, CXL, 29.

<sup>5</sup> Kennon Dunham. *Am. Jour. Roentgenol.*, IV, 280.

8 per cent were given a second dose the following day, and the 2 per cent of recurrent and post-paralytic cases were treated every ten days. In all of them, three doses were sufficient.

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### UNUSUAL FOREIGN BODY IN FOREARM

By GEORGE K. NUTTING, M.D., *Washington, D. C.*

From the Surgical Department of Georgetown  
University Hospital

A colored truck driver, aged 29 years, came to Georgetown Hospital complaining of a sore arm. Three days before admission to the hospital, a packing case fell from the truck and struck his arm. His history otherwise was negative, except that he said he had been

in an automobile wreck five months before, at which time his arm went through the windshield and the bleeding was so severe that it was necessary for the doctor to operate to stop the hemorrhage.

Examination of the forearm showed an elongated semicylindrical swelling over the middle third of the radial side of the extensor surface. The swelling was very tender to the touch and a long hard object could be palpated deep under the skin. X-ray films revealed a knife blade situated as shown in Figure 1 (See page 373.)

Under local anesthesia, a Russell stainless-steel knife blade was found embedded in firm, dense, fibrous tissue. When removed, the blade measured three inches in length.

This case is unusual and interesting in that the patient pursued a laborious occupation with such a large foreign body in his forearm.

and any untoward changes in other structures Douglas<sup>14</sup> states that collapse therapy is the greatest advance yet made in the treatment of pulmonary tuberculosis, and that it would be impossible to carry out such treatment satisfactorily without the aid of the roentgen ray

In the review of this subject we have been able to refer to only a few of the excellent contributions on this subject. It may be stated in general that, in many early cases, the roentgen examination may give the only evidence of disease. Activity or non-activity should not be decided from this examination alone, many so-called "silent" cavities will be seen which are not discoverable by other methods, and a proper appreciation of normal shadows is absolutely necessary in the diagnosis of chest roentgenograms.

It is a far cry from those early days of roentgenology when most clinicians looked with suspicion upon the attempt to diagnose pulmonary tuberculosis in cases which were negative to the usual clinical methods of diagnosis, to recent statements of Lawrason Brown,<sup>15</sup> as follows: "To refuse to accept this evidence places upon those who assume such an attitude the same responsibility as fell upon those who refused to accept the importance of the tubercle bacillus or of hemoptysis or of pleurisy, with or without effusion, in the diagnosis of pulmonary tuberculosis. We are in a new era in regard to the diagnosis of pulmonary tuberculosis and whether the value of the roentgen examination is accepted now or postponed for a decade or longer, the diagnostician and roentgenographer will eventually have to modify their practice and their technic to conform with it."

HOWARD P. DOUB, M.D.

Henry Ford Hospital  
Detroit, Michigan

## COMMUNICATIONS

### THE AMERICAN BOARD OF RADIOLOGY

The need for improved standards in the various medical specialties has become increasingly apparent during the past twenty years. Specialism is necessary in medical progress but evils have attended its development in this country, the worst of these being the assumption of the title "specialist" by men with inadequate training and experience. Methods of licensure for the practice of medicine in this country are so complicated, being under 49 different jurisdictions, that it has never seemed feasible nor advisable to attempt to bring specialists under legal control beyond that required by their license to practise medicine. Several of the specialties have attempted to bring about a measure of control and improvement within their own special fields by establishing examining boards to certify to the qualifications of specialists in their own branch of medicine. Particular credit is due to the pioneer board in ophthalmology which was organized in 1916, and to its Secretary, Dr. William H. Wilder, for assistance in the formation of succeeding boards in other specialties. After several successful years of operating the original Board of Ophthalmology, boards were formed successively for otolaryngology, obstetrics and gynecology, dermatology and syphilology, and for pediatrics. Radiologists wish to record their appreciation for the help and inspiration that they have received from the secretaries of all the established boards.

The desirability of instituting a board for radiology had been discussed for several years among radiologists, and the matter was brought to a head at the meetings of the American Medical Association and the American College of Radiology held in New Orleans, in 1932. At that time, committees were appointed by the College of Radiology and the Section on Radiology of the American Medical Association to investigate as to the advisability of forming such a board. At the suggestion of the Council on Medical Education and Licensure of the American Medical Association, this matter was brought to the attention of the American Roentgen Ray Society, the Radiological Society of North America, and the American Radium Society at their annual meet-

<sup>14</sup>B. H. Douglas. *Am Jour Roentgenol and Rad Ther*, XXX, 305.

<sup>15</sup>Lawrason Brown. *Am Jour Med Sci*, CLXXIIX, 700.



gen finding This exudation, beginning in a secondary lobule of the lung, is limited by the interlobular septa, unless cavitation occurs. It produces the fan- or cone-shaped shadow described by Dunham. Unfortunately, these fans may be seen in other diseases such as influenza, pneumonia, and pneumonococcosis. If they occur in the apical region and persist, there is a strong probability that they have a tuberculous etiology.

Fibrosis is indicative of an older lesion and shows evidence of partial or complete healing, the stage of which, in most instances, must be determined by clinical methods. Calcification denotes an older, healed process but does not rule out activity immediately adjacent. A safe rule is not to diagnose activity from the roentgen examination alone.

The term "peribronchial tuberculosis" has occupied a prominent place in the literature for many years. By this term was meant accentuation of the linear markings, often accompanied by studding or beading. Various authors advanced criteria by which these changes could be differentiated from the markings seen in normal individuals, but they have not stood the test of time. Pancoast,<sup>6</sup> in 1917, recognized this term but added that without tubercle bacilli this roentgenographic appearance cannot *per se* be regarded as indubitable evidence of a tuberculous etiology. Fales,<sup>7</sup> in 1926, stated that roentgenographic peribronchial infiltration is of no importance as pulmonary tuberculosis. It was not associated with tubercle bacilli in the sputum of any of his cases. Amberson,<sup>8</sup> after thoroughly covering the literature on the subject, in 1927, concluded that a diagnosis of peribronchial tuberculosis should not be reported, but that some term such as "peritruncal thickening" could be employed "in a descriptive sense to convey to the mind the idea of structural change, represented by accentuated and prolonged linear markings, with or without beading."

Just as incipient pulmonary tuberculosis can be detected roentgenographically earlier than by clinical methods, so will many cavities be visualized on the roentgenogram when they escape detection by physical examination. Amberson<sup>8</sup> has aptly stated that, "with the advent and perfection of the roentgen ray, however, few of these lesions should escape us

because, while sometimes 'silent,' they are rarely invisible." The recognition and changing features of pulmonary cavitation in the ordinary sense need no exposition to roentgenologists. Certain thin-walled circular shadows, which received the name of "annular shadows," evoked much discussion after their description by Sampson, Heise, and Brown,<sup>9</sup> who believed them to be due to localized spontaneous pneumothoraces and, therefore, relatively harmless. Amberson<sup>10</sup> believed some of these to be caused by localized pleurisy. Doub<sup>11</sup> demonstrated by films and autopsy specimens that certain of these shadows are due to emphysematous blebs. These, however, are more likely to occur in the bases.

The work of Burnham and Brown<sup>12</sup> and Dunham and Norton<sup>13</sup> has demonstrated quite conclusively that not only may cavities have thin walls and show very little infiltration about them, but that they may appear and disappear with relative quickness. There is every probability that circular shadows occurring in conjunction with pulmonary tuberculosis are true cavities and only in rare instances can they be attributed to pleural lesions.

The scope of this communication does not permit a complete exposition of the roentgen findings in the various manifestations of pulmonary tuberculosis, nor the relation of the pleural reaction, the apical cap, and other associated conditions. Most of the discussion above has to do with the original diagnosis of the pulmonary lesion. In addition to this, the roentgen examination is unexcelled in noting the progress of the lesion under treatment. From the basic concept, that rest of the involved part is the greatest aid in healing, has evolved the more recent collapse therapy. By this is meant such procedures as artificial pneumothorax, paralysis of the diaphragm from surgery upon the phrenic nerve, and thoracoplasty, which procedures have made progressive roentgen examinations of paramount importance in judging the amount of collapse, the effect on the lesion and the opposite lung,

<sup>9</sup> H. L. Sampson, F. H. Heise, and L. Brown. *Am Rev Tuberc.*, II 664.

<sup>10</sup> J. B. Amberson. *Am Jour Roentgenol and Rad Ther.*, XII 438.

<sup>11</sup> H. P. Doub. *Am Jour Roentgenol and Rad Ther.*, XX 6.

<sup>12</sup> M. P. Burnham and P. K. Brown. *Am Rev Tuberc.* VI 469.

<sup>13</sup> H. K. Dunham and V. V. Norton. *Am Rev Tuberc.*, X 306.

<sup>6</sup> H. K. Pancoast. *Am Jour Roentgenol.*, IV 462.

<sup>7</sup> L. H. Fales. *Am Jour Med Sci.* CLXXII, 382.

<sup>8</sup> J. B. Amberson. *Am Jour Roentgenol.* XVII

functioning of the American Board of Radiology

1 Certification by the Board furnishes a criterion to both lay and professional groups for judging a radiologist's qualifications

2 Hospitals and other organizations will gradually establish rules limiting service on their staffs to those certified by the Board

3 It will gradually tend to limit specialization to those who are qualified to practise this specialty

4 National and other special societies will eventually limit their membership to those who hold the Board's certificate

5 The laity will gradually become informed of the importance of choosing specialists who are certified by the Board

6 Physicians, in choosing consultants and in referring patients, will gradually turn to those who are certified and thus help to eliminate those who are not qualified to practise radiology

The first examination will be held in Cleveland, Ohio, immediately preceding the meeting of the American Medical Association, in June, 1934

The members of the Board are as follows

H K Pancoast, M D, *President*, Philadelphia

A C Christie, M D, *Vice-president*, Washington, D C

B R Kirklin, M D, *Secretary-Treasurer*, Rochester, Minn

E C Ernst, M D, St Louis

G W Holmes, M D, Boston

E L Jenkinson, M D, Chicago Ill

L C Kinney, M D, San Diego, Calif

W F Manges, M D, Philadelphia

L J Menville, M D, New Orleans

J W Pierson, M D, Baltimore, Md

L R Sante, M D, St Louis

Henry Schmitz, M D, Chicago

Albert Soiland, M D, Los Angeles, Calif

M C Sosman, M D, Boston

R H Stevens, M D, Detroit, Michigan

All radiologists interested should write to B R Kirklin, M D, Secretary, Mayo Clinic, Rochester, Minnesota

## RADIOLOGICAL SECTION OF THE LOS ANGELES COUNTY MEDICAL ASSOCIATION

The following are the present officers of the Radiological Section of the Los Angeles County Medical Society Orville Meland, M D, *President*, Clayton Johnson, M D, *Vice-president*, E N Liljedahl, M D, *Secretary*, Henry Shure, M D, *Treasurer*

## THE ZURICH CONGRESS

Word has just been received in this country from Zurich that up to Jan 30, 1934, only twelve Americans had registered for the Fourth International Congress of Radiology at Zurich At each one of the former Congresses, the United States has furnished not less than one hundred delegates and it is in all respects desirable that an equal number be present this year We desire to call attention to the importance to American radiologists of a goodly representation The program this year will be of unusual interest and scope

All interested are urged to communicate at once with Dr H E Walther, General Secretary, Fourth International Congress of Radiology, at Gloriastrasse 14, Zurich, Switzerland

## BOOK REVIEWS

COMPENDIO DI RADIOLOGIA MEDICA PROF G B CARDINALE and DOTT MARIO MAINO Preface by PROF VITTORIO MARAGLIANO A volume of 493 pages and 330 illustrations, with one colored table Published by Ulrico Hoepli, Milan, 1934 Price, \$4 00 (60 lire)

This Italian text-book on roentgen diagnosis, written especially for medical students and the general practitioner, presents the entire subject in a very detailed and practical manner The text, which is replete with many fine illustrations, is arranged in eight parts which concern roentgen-ray technic, physics, and roentgen diagnosis as related to each of the various systems of the body In the two concluding chapters the authors have discussed the clinical applications of roentgentherapy In spite of the fact that this volume was written primarily for medical students and the general practitioner, as mentioned above, the text is most comprehensive and contains much that will interest the radiologist as well

ings, and each of these societies likewise appointed a committee to investigate the advisability of forming such a board.

The committees representing these five radiologic organizations met on June 11, 1933, in Milwaukee, during the meeting of the American Medical Association. They effected a preliminary organization and adopted the following recommendations to be presented to each of the five associations represented:

(1) "That it is the sense of this joint committee that a national examining board for radiologists be formed,

(2) "That it be recommended to each of the five societies here represented that three members be appointed by each of the societies to constitute a national examining board for radiology,

(3) "That the purpose of the Board shall be the examination and certification of radiologists,

(4) "That the Board thus formed be authorized to effect its own organization, elect officers, adopt rules of procedure, and proceed to the examination and certification of candidates."

The above recommendations were approved by each of the societies, namely, the American College of Radiology, the American Roentgen Ray Society, the American Radium Society, the Radiological Society of North America, and the Section on Radiology of the American Medical Association. Three members were appointed from each of the societies to form the Board.

The organization meeting of the Board was held at the Palmer House, in Chicago, on September 28, 1933, during the first American Congress of Radiology, and H. K. Pancoast, M.D., was elected President of the Board and B. R. Kirklin, M.D., Secretary-Treasurer. A committee consisting of W. F. Manges, M.D., A. C. Christie, M.D., and John W. Pierson, M.D., was appointed to draw up by-laws and secure the incorporation of the Board.

The Board met again in Washington, D. C., on January 27 and 28, 1934, at which time by-laws and articles of incorporation were adopted. The following permanent officers were elected: H. K. Pancoast, M.D., President, A. C. Christie, M.D., Vice-president, and B. R. Kirklin, M.D., Secretary-Treasurer.

The purposes of the Board according to the by-laws are as follows:

"(a) To elevate the standards and advance the cause of radiology by encouraging its study and improving its practice,

"(b) To test the qualifications of those who profess to be specialists in radiology by arranging and conducting examinations of voluntary applicants for the certificate of the Board, and to issue certificates to those found qualified therefor,

"(c) To prepare and maintain a registry of holders of the certificate of the Board,

"(d) To serve the public, physicians, hospitals, and medical schools by furnishing lists of those who have received the certificate of the Board and thus to assist in protecting the public against irresponsible and unqualified practitioners who profess to be specialists in radiology."

The rules of the Board require that applications for certificates be made upon a prescribed form to be secured from the Secretary.

Each applicant must establish, to the satisfaction of the Board, that he is of high ethical standing, a graduate of a medical school approved by the Board, a member of at least one of the societies which appoint members of the Board, has had satisfactory experience in the practice of radiology, and that he is a physician duly licensed to practise medicine.

The by-laws of the Board provide that "each applicant for the certificate of the Board shall be examined in such manner and under such rules as the Board may prescribe, due weight being given in each individual case to professional attainments, years of training and practice, teaching and other positions held." It will be understood from this that the Board intends to fix the extent and the scope of the examination in each individual case. The successive steps in a *complete* examination are as follows: (1) Submission to the Secretary of the prescribed application form properly filled out, (2) submission to the Secretary of reprints or original thesis, (3) personal appearance before the Board for oral and practical examination.

The candidate will be informed after each successive step what is further required of him.

The experience of the Boards already functioning has been very satisfactory, and it is the general opinion that they have served to improve conditions in each specialty represented. Based upon their experience, the following advantages may be expected from the

that the various scientists could not be convinced of the importance of Röntgen's discovery until they had proof of its practicability as demonstrated by roentgenograms of the human hand. The practical application, as suggested by the pictures, immediately stimulated scientific and general interest and, except for them, the discovery might have been confined to the relative oblivion of the physical laboratory for some time.

The chapter on Röntgen's life is unusually comprehensive and very well written. It is unfortunate that his last years were made unhappy by the World War and by the economic collapse of Germany. At the time of his death his private fortune consisted of 339,000,000,000 paper marks and bonds with a value of 3,654 gold marks.

The accounts of Röntgen's discovery in the daily press and in popular magazines and in "Contemporary Humor" make very interesting reading, and show quite plainly that the lay mind was unable to grasp the true significance of the discovery.

The careful manner with which the author has verified all his statements indicates beyond question the reliability and authenticity of the biography. Especial mention should be made of the extensive bibliography and its orderly arrangement. The illustrations have been carefully chosen for their historic interest. Many of them are published in this book for the first time.

The radiologist who has not read this book has missed one of the outstanding contributions to x-ray literature.

THE VALUE OF ROENTGEN EXAMINATION IN PULMONARY DIAGNOSIS. A ROENTGENOLOGIC-ANATOMIC COMPARISON (Der Wert der Röntgenuntersuchung in der Lungen-diagnostik. Ein Röntgenologisch-Anatomischer Vergleich). By TORLEIF DALE, from the Röntgen-Radium-Institut des Rikshospitalets, Oslo. Acta Radiologica, Supplement XVI, paper-bound volume, 111 pages with 57 illustrations, 14 of which are stereoscopic. Published by Kungl. Boktryckeriet, P. A. Norstedt & Söner, Stockholm, 1932. Price, Swed. cr 10.

In his foreword, Dale explains that the longer he studied pulmonary roentgenograms the greater were his doubts and uncertainty concerning their significance. His interest lies in the interpretation of the pathologic-anatomic substratum of pulmonary findings. He feels

that in pulmonary roentgenography one is handicapped by the fact that confirmation of diagnosis usually must rest upon physical findings, not, as is often the case in other regions of the body, upon surgical or necropsy findings. He calls attention to the mechanical difficulties in pulmonary interpretation which result from the overlapping on the roentgenogram of certain parts of the lung parenchyma and the thoracic wall.

In 1928, the author began his comparative study of the lungs by means of pathologic-anatomic and roentgenologic examinations. He had as his goal the answers to two questions: (1) What anatomic substratum have the changes which are found on the pulmonary roentgenogram? and (2) Which changes may be diagnosed on the pulmonary roentgenogram and which lie outside the diagnostic sphere of roentgen examination?

Dale's experimental work incorporated two processes. In the first his subjects were medical students with well-developed thoraces and of normal body weight. The procedure was as follows: first, the *intra vitam* injection of 50 c.c. of 40 per cent abrodil solution, and then stereo-roentgenograms of the lungs made during deep inspiration. His second study was upon roentgenograms of cadaver lungs made one to two hours after death. For this, he photographed the lungs *in situ* and then removed the lungs, heart, and neck organs together, with a clamp over the aorta and vena cava, and above the diaphragm. The excised lungs were then inflated by means of a blood pressure pump controlled by a manometer, and stereo-roentgenograms were made using the same factors as those used for the lungs *in situ*. Dale feels that roentgenograms should be made and the examination of pathologic material should be begun as soon as possible, generally not longer than twelve hours after death. This is essential to preclude *post-mortem* changes. His stereo-roentgenograms of excised lungs were made with the lungs placed upon a wooden board in which small steel wires were embedded so that they were projected onto the roentgenogram like a lattice. Later, when the lungs were frozen in the same position, the wires served as a guide for the comparative study of the specimen. To study the interlobar fissures, Dale used Kerr's paste inclosed within the fissures and subsequent photographs made in various directions.

This is a detailed method by which the author emphasizes some very valuable facts that have

**ROENTGENOTHERAPY IN TABLE FORM** DR EMMERICH MARKOVITS, Chief of the Roentgenologic Laboratory in the State Hospital and Poorhouse in Budapest. A volume of 153 pages, with 40 figures, paper. Published by Georg Thieme, Leipzig, 1934. Price M 10 80

In this German book Markovits has briefly stated a method of treating various lesions with roentgen rays. For those who desire a schematic tabulation of the method of roentgenotherapy, this book contains much valuable information, but for the specialist it is not of much importance.

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**RADIODIAGNOSIS IN INFANTS VOLUME I, PELVIS AND LOWER EXTREMITIES** By MANUEL and FRANCISCO ARCE, Radiologists to the Infant Jesus Hospital, Pediatric Clinic of the Faculty of Medicine of Madrid, and Asylum of San Rafael. Preface by DR D. ENRIQUE SUNER, Ordinary Professor of Pediatrics, Faculty of Medicine of Madrid. A volume of 285 pages and 210 illustrations. Published by Ediciones Boro, Madrid, 1933. Price not stated.

This volume in which the authors review the roentgen pathology of the pelvis and lower extremities of infants is the first of a series of Spanish monographs to follow, concerning the roentgen pathology of childhood diseases. The first part of this monograph contains a complete description of the radiographic technique used and a discussion of the normal development and anomalies of the pelvis and lower extremities. The chapters which follow are devoted to a consideration of osseous lesions occurring in children. The syphilitic lesions which the authors classify as early and late manifestations are unusually well discussed and illustrated. The book contains many excellent illustrations and should prove useful to radiologists as well as pediatricians.

---

**RADIOGRAPHIC STUDY OF THE NORMAL AND DISEASED BREAST** DR ALEXANDRE ESPAILLAT-G., Faculty of Medicine of Paris, Certified Electro-radiologist of the Faculty of Paris. Work from the Surgical Clinic of Professor Gosset and the Clinico-radiologic Laboratory of the Faculty (Dr Ledoux-Lebard, Chief of Staff). A volume of 154 pages and 18 illustrations. Published by Librairie Louis Arnette, Paris, France. Price Not stated.

This is a complete and detailed French monograph concerning diseases of the breast.

The author has outlined the various anomalies of the human breast in a simple and clear-cut manner, so that the reader is able to grasp the radiologic manifestations quite readily. The radiographic technique is slightly different from that used in America in that the film is placed upon a block at an angle of 45° to the table, and the radiation passes through the breast and axillary structures at an angle of about 60°, judging from the illustration. He varies the quality of the radiation according to the pathology, and other anomalies present, and uses the stereoscopic technique.

He discusses, at considerable length, the normal female breast and changes brought about by menstruation and pregnancy and senility in the normal, and gives some most interesting illustrations of various non-malignant and malignant conditions. He also includes case histories of 41 patients in which the clinical, radiographic, and pathologic diagnoses (where possible) are correlated. The bibliography is complete.

The monograph is well worth reading for a complete review of the subject.

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**WILHELM CONRAD RÖNTGEN AND THE EARLY HISTORY OF THE ROENTGEN RAYS** By OTTO GLASSER, with a chapter entitled "PERSONAL REMINISCENCES OF W. C. RÖNTGEN," by MARGRET BOVERI, of Berlin. A volume of 494 pages and 96 illustrations. Published by Charles C. Thomas, Springfield, Ill. Price, \$6 00.

This unusually interesting biography of Wilhelm Conrad Röntgen, by Glasser, begins with the dramatic discovery of the roentgen rays in 1895. The account of the discovery has been presented in an orderly and painstaking manner and the author has left no stones unturned to verify all statements. It should clear up many of the controversies now in existence, and in the future will undoubtedly be accepted as authentic. In the first chapter an interview with Röntgen by H. J. Dam, which appeared in "McClure's Magazine" in 1896, appealed to the reviewer as one of the high-lights of the book.

There is included in full the three communications of Röntgen concerning his discovery, together with the first impressions of the news of his discovery on the world. It would seem

that the various scientists could not be convinced of the importance of Röntgen's discovery until they had proof of its practicability as demonstrated by roentgenograms of the human hand. The practical application, as suggested by the pictures, immediately stimulated scientific and general interest and, except for them, the discovery might have been confined to the relative oblivion of the physical laboratory for some time.

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This is a detailed method by which the author emphasizes some very valuable facts that have

been noted often by the American roentgenologists. The study of the lungs after death by air inflation and roentgenography is a procedure which has been used extensively in this country, and there have been reports of *ante* and *post-mortem* studies of the same cases. There have been numerous articles concerning the differential diagnosis of pulmonary cavities and the various types of tuberculosis, as well as constant stressing of the importance of continual comparison of necropsy material and roentgen findings. Dale refers to the confusion arising

from superposition of vessel shadows. One American investigator carefully injected the blood vessels and air passages of the lungs after death, roentgenographed at each step of the process, and showed the possibility of error in interpreting these vessels as abnormal findings.

The article is documented with a well abstracted bibliography of 139 references, only ten of which, however, are from the American literature. The monograph is painstakingly written and represents great outlay of time and study.

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J. E. HABBE, M.D., of Milwaukee  
H. W. HEFKE, M.D., of Milwaukee

DAVIS H. PARDOLL, M.D., of Chicago  
ERNST A. POHLE, M.D., Ph.D., of Madison, Wis.  
CHARLES G. SUTHERLAND, M.D., of Rochester, Minn.

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## ARTHRITIS

Rheumatoid Arthritis Russell L Cecil Jour Am Med Assn, April 22 1933, C, 1220

The author presents a classification unanimously agreed on by a group of men especially interested in arthritis

- 1 Infectious (a) rheumatic fever, (b) rheumatoid arthritis, (c) arthritis caused by specific organisms

- 2 Degenerative Osteo-arthritis (hypertrophic arthritis)
  - 3 Allergic Serum sickness
  - 4 Traumatic
  - 5 Metabolic (a) gout, (b) scurvy, (c) rickets
  - 6 Neurogenic arthropathy, including syringomyelitis, Charcot's post-hemiplegia, etc
- He divides the subject into age groups
- Age 2 to 5 years, Still's disease
  - Age 5 to 20 years, rheumatic fever
  - Age 20 to 50 years, rheumatoid arthritis
  - Age 50 to 70 years, osteo-arthritis

Rheumatoid arthritis is primarily a disease of the synovial membrane and other soft parts of the joint, while osteo-arthritis is a disorder of the articular cartilage and adjacent bone. Cartilage and bone may become involved in the later stages of rheumatoid arthritis, while osteo-arthritis may be complicated occasionally by hydrops or by thickening of the synovial membrane. The anatomic differences are well brought out by radiography. In rheumatoid arthritis there is a haziness of the interarticular space and rarefaction of the bone. In the later stages the destruction of cartilage leads to close apposition and possible fusion of the articular surfaces. In osteo-arthritis, bony spiculation and hypertrophy of the articular margins are visible, even in the early stages. Later on, there is an increased osseous overgrowth at the joint margins, accompanied by degeneration and thinning of the cartilage. In osteo-arthritis, fusion of the articular surfaces does not occur. Rheumatoid arthritis is an inflammatory disease and its clinical course is that of an infectious process. Hypertrophy or osteo arthritis appears to be a phase of senescence. It is possible that certain toxic or metabolic factors accelerate the process, but the picture is not that of an infection. The rational treatment of rheumatoid arthritis embraces removal of foci of infection, emphasis on rest, and a general building up program, consisting of carefully regulated diet, vitamins, iron and arsenic and adequate elimination through the intestine, bladder, and skin. Vaccines, physical therapy, and, in advanced cases, surgery are comprehensively reviewed as to their efficacy.

C G SUTHERLAND, M D

Visibility of the True Joint Space in Arthritis Deformans G von Pannewitz Röntgenpraxis, November, 1933, V, 809, 810

Roentgenograms of the knee joint, showing the true joint space without contrast filling, have been described by Dittmar. The author has seen the same phenomenon in five cases, four times in the knee and once in the shoulder joint. It has been thought that an especially favorable projection was necessary, but in the cases seen by the author the same picture could be reproduced without paying any attention to special positions. It was also evident that the joint space became more easily demonstrable in time. Often it is possible to see the menisci, just as they might be shown after air injection into the joint. All cases seen by the



author were suffering from an arthritis deformans. It seems reasonable to assume that the appearance of the true joint space might be due to an increased density of the cartilage of the joint, which might be based on pathologic changes. The subject needs further observation and study.

H W HEFKE M D

## BONES, ABNORMALITIES

The Os Epipyramis. Report of a Case. Albert B Ferguson. *Jour Bone and Joint Surg*, October, 1933, XV, 1001, 1002.

The author reports a case of the occurrence of the os epipyramis, an anomalous bone of the carpus. This anomaly had previously been described by Pfitzner, Dwight, Grumbach, and Heimerzheim. In the author's case the epipyramis was 2 mm in diameter, oval in shape, and situated in the space between the left lunate, triangular, and hamate bones. There was no evidence of traumatism to this region.

J N ANÉ, M D

## CONTRAST MEDIA

The Differential Diagnosis of Diseases of the Liver and Spleen by the Aid of Roentgenography after Intravenous Injection of Thorotrast (Thorium Dioxide Sol). Wallace M Yater and Laurence S Otell. *Am Jour Roentgenol and Rad Ther*, February 1933, XXIX 172-181.

For hepatosplenography, daily injections for three days are made, using each time 25 c.c. thorium dioxide solution (thorotrast). Films are taken with the patient in the anteroposterior and postero-anterior positions, any time after four or more hours following the third injection. Only three patients out of a series of 40 studied by this method had undesirable reactions. In the authors' opinion, indications for this method of investigation are (1) any liver enlargement of unknown origin, (2) upper abdominal masses which might be liver or spleen, (3) clinical suspicion of liver abscess, (4) suspected metastatic carcinoma of the liver, (5) the existence of known hepatic disease, and the desire to follow its progress, (6) splenomegaly of unknown origin, (7) suspected ascites, and the attempt to prove its presence. Contra-indications are (1) a moribund state of the patient from any cause, (2) known severe liver and kidney insufficiency.

Illustrations include cases of malignancy, cirrhosis, lobe anomalies, and ascites.

J E HABBE, M D

## FOREIGN BODIES

Roentgen Diagnosis and Localization of Opaque Foreign Bodies in the Air Passages. Willis F Manges. *Am Jour Roentgenol and Rad Ther*, March 1933, XXIX 368-383.

While the aspiration of foreign bodies into the bronchi is usually immediately accompanied by an attack of

choking and later by recurrent attacks of coughing, the presence of the foreign body in the lung may remain unsuspected for months or even years, particularly in the cases of children. There is apt to be intermittent febrile reaction during which clinically there may develop bronchitis, pneumonia, abscess, or asthma. Of the many foreign bodies entering the respiratory tract all but perhaps 2 or 3 per cent are retained indefinitely, this very small percentage being expelled spontaneously by coughing. The majority of foreign bodies, especially the opaque (metallic) ones, pass into the lower lobe bronchi. A localized infectious process, especially in the inner posterior portion of either lower lobe, should be looked upon as a reaction to a possible foreign body until other origin can be shown. A case of an adult with a shawl pin in a bronchus which the patient was completely unaware of having aspirated, is cited to emphasize that even adults may harbor foreign bodies in the lungs without being conscious of having aspirated them. Localization of an opaque foreign body in the absence of co-existing lung pathology is a relatively simple technical procedure. However, it is important that this procedure be carried out just prior to bronchoscopy because a definite percentage of these foreign bodies shift from one bronchus to another without creating any definite disturbance. Metallic foreign bodies may remain in the bronchi for years without producing extensive damage, yet on the other hand some cases develop extensive infection, necrosis and fibrosis. Rarely, perforation of the pleura may occur with the development of pneumothorax or pyothorax.

J E HABBE M D

## GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Clinical and Roentgenologic Diagnosis of Intercostal Position of the Colon. M J Goldstein and Dm Goldstein. *Röntgenpraxis* December, 1933, V, 877-881.

The anomalous position of parts of the colon between the liver and the diaphragm, called interposition of the colon, is most often seen in persons of mature or advanced age. Only rarely has it been reported in children. It may be temporary or permanent. In some cases there are no symptoms and the roentgenologic finding is accidental, in others, the interposition may lead to a number of cardiac symptoms, while in a third group this lesion is combined with gastric or duodenal ulcers. A few cases seem to be due to pleuro-diaphragmatic adhesions. In the differential diagnosis, sub-diaphragmatic abscess, spontaneous pneumoperitoneum, gas-filled intestinal cysts and diaphragmatic hernia must be considered.

H W HEFKE M D

Diverticula of the Colon and Their Complications. Ernst Schiffer. *Röntgenpraxis* December 1933, V 865-877.

There are three groups of diverticula of the colon (1) the true diverticula, the walls of which contain all

the layers of a normal colon and which are congenital (so rare that they are of no practical importance), (2) diverticulum-like sacculations after pericolic adhesions, also of no clinical importance, (3) pseudo-diverticula, which are really only herniations of the mucosa, but are commonly called diverticula. They are found mainly in places where blood vessels penetrate the muscular layer. Their etiology is not clear. Constipation, with increased pressure in the colon, local inflammatory processes, focal infection, congenital disposition, etc., have been said to be the causes. The roentgenologic demonstration of diverticula without clinical symptoms is a frequent occurrence (diverticulosis). Some authors acknowledge the existence of a prediverticulosis when the contour of the sigmoid is irregular and the transverse mucosa folds are increased. There might be one or many diverticula, most frequent in the sigmoid, next in the descending and transverse colon, and comparatively few in the ascending colon and appendix. A colitis diverticulosa or diverticulitis presents a typical roentgen appearance. There is spasm, change of the mucosa relief, and tenderness. An indurative inflammatory process may lead to an organic stenosis. Perforation of infected diverticula may cause localized abscesses or peritonitis, which require surgical measures. The roentgenologic diagnosis of diverticulosis (the only possible means of diagnosis) should mean the establishment of prophylactic measures, as anticonstipation diet, mineral oil, and so forth. The barium enema is much more reliable for the diagnosis of this disease than examination of the colon after a barium meal. Described in detail are 14 cases of diverticulitis, diverticulosis, and their complications.

H W HEFKE, M D

### GENITO-URINARY TRACT (DIAGNOSIS)

The Value of the Roentgen Ray in the Diagnosis of Renal Tuberculosis. Charles A Waters. *Am Jour Roentgenol and Rad Ther*, January, 1933, XXIX, 17-23.

It has been stated that the incidence of genito-urinary tuberculosis in postmortem examinations of individuals showing active or quiescent tuberculosis elsewhere may be as high as 10 per cent, males being involved about four times as frequently as females, and the right kidney about three times as often as the left. In a large majority of the cases of renal tuberculosis the original infection (usually in the respiratory tract) is quiescent and often not suspected.

X-ray evidence of renal tuberculosis is in the nature of either calcification in the renal cortex or of a "fringed" appearance of one or more minor calices upon pyelogram examination, the latter appearance being the result of tuberculous destruction of the tip of the papilla which lies in the cup of the calyx. Later fibrosis and strictures may also develop, alternating areas of narrowing and dilatation of the ureter. With recent hematuria one must expect occasionally to see filling

defects in the pelvis as a result of the blood clot. In the author's series of 35 cases, 70 per cent showed positive pyelographic findings while 40 per cent showed areas of cortical calcification. It is believed that there are no contra-indications to this method of investigation when properly performed.

J E HABBE, M D

### HEART AND VASCULAR SYSTEM

Roentgen Therapy of Rheumatic Heart Disease. A Review of Six Years' Experience. Robert L. Levy and Ross Golden. *Am Jour Roentgenol and Rad Ther*, January, 1933, XXIX, 79-82.

The authors report on their results of radiation therapy for rheumatic heart disease. By using single fields, anteriorly and posteriorly, they attempt to deliver 10 per cent of a skin erythema dose through the heart region, using penetrating rays generated by 200 K V (peak) through 0.5 mm copper. Such radiation is repeated at intervals of two weeks until four such series have been given.

During the last five and three-fourths years, 32 patients have been treated by this method. In 17, improvement has been observed, while five cases show striking relief of paroxysmal angina. Patients in the first attack of rheumatic fever, with slight cardiac involvement, offer the best chance for successful therapy by this method.

J E HABBE, M D

### THE KIDNEYS

Carbuncle of the Kidney (Metastatic Staphylococcus Abscess of the Kidney). William N Taylor. *Am Jour Surg*, December, 1933, XXII, 550-556.

Carbuncle of the kidney is accepted as a distinct pathologic and clinical entity, a localized phlegmon of the kidney. There are no clinical symptoms or physical findings which differentiate it from other hematogenous infections of the kidney. The diagnosis is difficult but is suggested by the presence or antecedence of a superficial staphylococcal infection, usually of the skin. Trauma has seldom been recorded as playing an important rôle in its production.

Herein is reported a case in which there was no antecedent infection—there was a definite history of trauma, a microscopic hematuria, a pyelogram which showed pelvic distortion, and an incorrect diagnosis of renal neoplasm. Treatment consisted of nephrectomy, with complete recovery.

DAVIS H. PARDOLL, M D

### PEPTIC ULCER (THERAPY)

A Case of Large Non-malignant Gastric Ulcer and a Case of Large Duodenal Ulcer, with Fatal Hemorrhage. George N. Burger and Paul Merrell. *Jour Am Med Assn*, Feb 4, 1933, C, 336.

A case of gastric ulcer in a patient, aged 58, who had given a history of 33 years of aching or "tearing pain"

in the epigastrium is reported. At autopsy a stomach ulcer was found, measuring  $6 \times 11$  cm, extending to within 2 cm of the pylorus. Microscopic examination showed no evidence of neoplasm.

The other case reported is that of a duodenal ulcer in a male, aged 64, who, 30 years before, had been treated for peptic ulcer, for which he had been hospitalized for nine months. He was well until six weeks before the present admission, when he developed severe epigastric pain, nausea, and vomiting within from 15 to 20 minutes after meals, loss of appetite and hiccoughing. Death followed, and autopsy showed a large ovoid ulcer, 1 cm from the pylorus, measuring  $2.5 \times 5$  cm, with distinctly indurated edges perforated on to the pancreas. Both patients presented advanced arteriosclerosis.

C G SUTHERLAND, M D

## THE PROSTATE

Choice of Procedure in Cases of Prostatic Obstruction. N P Rathbun. *Am Jour Surg*, October, 1933, XXII, 100-112.

The author stresses the fact that prostatism provides us with a wide variety of problems—we have available a wide variety of methods of treatment and it devolves upon us to make every effort to elect a procedure which is best adapted to each individual case.

He realizes that a larger quantity of statistical evidence would probably be more convincing yet his paper is more or less a philosophic contemplation rather than a statistical analysis of the entire problem. He expresses his personal views upon a few of the moot points in an effort to provide a suitable groundwork upon which to base a profitable discussion.

This is a most excellent article, without over-enthusiasm for any single procedure, and well worth while reading.

DAVIS H. PARDOLL, M D

## RADIATION EFFECTS

Shifting of Pigment in the Nipple following Roentgen Treatment. E. Saupé. *Strahlentherapie*, 1933, XLVI, 397, 398.

A man 59 years of age was treated over the anterior upper mediastinum the right lower corner of the field reaching the right nipple. Several months after the first treatment there was a marked increase in pigmentation in that part of the right nipple which was within the exposed area, while pigmentation from the remaining part of the nipple had almost disappeared.

ERNST A. POHLE, M D, Ph D

The Influence of Roentgen Rays on the Action Current of Nerves. W. Schmitz and H. Schaefer. *Strahlentherapie*, 1933, XLVI, 564-567.

The action current in the ischias nerves of frogs under the influence of roentgen rays was studied by the authors. Doses up to 1000 r per minute and a total dose of 5000 r were used (110 K V, 10 ma, 20 cm

field, 1 mm Al). No direct primary influence on the nerve from doses as used in therapy could be detected.

ERNST A. POHLE, M D, Ph D

Roentgen Therapy of Neuralgia of the Trigeminal Nerve. Rudolf Hummel. *Strahlentherapie*, 1933, XLVII, 684-688.

During the period from 1922 to 1932, 36 patients were treated in the author's clinic for neuralgia of the trigeminal nerve. Technic: 160 K V, 4 ma, 30 cm FSD, 0.5 mm Al,  $6 \times 8$  sq cm field of entry over the temporal area, 200-250 r per sitting to be repeated three times at eight-day intervals. Twenty-seven cases were used in the statistics of end results. Five (18.6 per cent) patients were cured, in another like group there was marked improvement, and in 40.6 per cent of the patients there was temporary improvement lasting from four to twelve months. In six cases (22.2 per cent), the treatment was not successful.

ERNST A. POHLE, M D, Ph D

Effect of Roentgen Rays on the Cholesterol Metabolism and its Compensation by Lipoid Feeding by Mouth. Magda Kiesel. *Strahlentherapie*, 1933, XLVI, 311-342.

The cholesterol content of the plasma was studied in rabbits and humans before and after irradiation, with and without cholesterol feeding. Although the findings did not point in one direction, the author feels that one may expect a cholesterol drop after roentgen irradiation. This is usually followed by roentgen sickness. If cholesterol is given by mouth, it is often possible to avoid the systemic reaction. Emphasis is laid upon the fact that no difference in the behavior of the cholesterol content could be seen between patients with and without carcinoma.

ERNST A. POHLE, M D, Ph D

Roentgen Therapy in Furunculosis of the Face. W. Baensch. *Strahlentherapie*, 1933, XLVII, 188-194.

The author studied the effect of roentgen rays on furunculosis of the face by comparing 103 patients which were treated with 103 untreated controls. Conservative treatment of non irradiated furuncles of the face had a mortality of 10.7 per cent, while irradiated patients showed only 1.9 per cent mortality. In 87 per cent there was a definite beneficial effect of irradiation. The pain subsided and within a few hours after exposure the temperature dropped to normal and the course of the illness was materially shortened. The majority of the cases received 150 r through 1.5 Zn + from 3 to 5 mm Al at 30 cm distance, sometimes a dose of as much as 250 r was applied.

ERNST A. POHLE, M D, Ph D

The Present Status of Roentgen Therapy of Non-malignant Diseases in Women. C. J. Gauss. *Strahlentherapie*, 1933, XLVII, 144-159.

The author discusses briefly the use of roentgen rays

in the following conditions uterine fibroids, uterine hemorrhage, disturbances during pregnancy, and sterilization, temporary as well as permanent. Small doses applied to the ovaries and the effect of roentgen rays in inflammatory diseases are also mentioned. The author discusses the use of radiation in diseases of the vulva followed by indications for exposing hypophysis, thyroid, thymus, spleen, liver, breast, kidneys, bladder, and finally the vegetative nervous system.

ERNST A. POHLE, M D, Ph D

Folliculitis with Pseudo-tumor Formation in a Patient with Radio-epidermitis Sicca. G. Schwarz and A. Frank. *Strahlentherapie*, 1933, XLVII, 195-200.

A patient 77 years of age, with carcinoma of the left tonsil, was observed following x-ray therapy in high doses (5,300 r) over the cervical areas. The left side received the higher dose and showed marked reaction. That on the right was milder, but directly below the mandible there appeared a plum-sized swelling which started to ulcerate at the surface. A tentative diagnosis of metastases in the glands was made, but tissue curetted from the surface did not show malignant cells. Within a week the growth had reduced considerably in size and the necrotic area healed. Therefore, it must have been a folliculitis which was naturally mistaken for a malignant involvement of the gland.

ERNST A. POHLE, M D, Ph D

## RADIATION SICKNESS

Roentgen Sickness and its Treatment with Cardiazol-ephedrin. Waldemar Hug. *Strahlentherapie*, 1933, XLVII, 708-714.

The author recommends Cardiazol-ephedrin in solution or in the form of tablets (1 tablet = 1 cc = 0.1 g Cardiazol + 0.015 g ephedrin hydrochlor) for the treatment of roentgen sickness. In a series of 50 cases it proved to be most effective.

ERNST A. POHLE, M D, Ph D

Liver Extract in the Treatment of Roentgen Sickness. F. G. Dietel. *Strahlentherapie*, 1933, XLVIII, 110-113.

The author states that in 15 female patients the symptoms of x-ray sickness disappeared within an hour after injection of from 2 to 4 cc of liver extract.

ERNST A. POHLE, M D, Ph D

## RADIUM

Morbidity and Mortality in Radium Treatment of Carcinoma of the Uterus. E. Wagner. *Strahlentherapie*, 1933, XLVII, 651-657.

In the author's clinic 127 patients (114 with carcinoma of the cervix and 13 with carcinoma of the fundus) were treated with 322 radium applications. In 62 instances a slight elevation of the temperature was noted, and 10 times high temperature was observed for a longer period of time.

There was not a single case of death in this series.

ERNST A. POHLE, M D, Ph D

Radium Therapy of Circumscribed Keratosis. Herbert Fuhs. *Strahlentherapie*, 1933, XLVIII, 194-198.

The author treated 280 cases of clavi with radium. In eight cases the lesion was on the dorsum of the toes and in twelve at the lateral aspect of the toes, none of which responded to treatment. Of the entire group, 29 had lesions between the toes and three of those were cured (10 per cent), 231 had lesions on the plantar surface and 98 per cent of these were cured. He also reports on 154 patients with verruca. He treated 46 cases of verruca planae juvenilis, with 39 lesions on the face and seven on the hands. In the first group, 80 per cent and in the second location 71 per cent were cured. The second group of verruca vulgaris subdivided into lesions around the nail and those in other parts of the body, particularly the face and hands. In the first subdivision numbering 29, 93 per cent showed a cure, and among 79 belonging to the second subdivision 67 per cent responded to the treatment. Radium therapy of clavi and verruca is, therefore, the method of choice. The author used from 50 to 100 mgh at 1 cm distance, filtered through 0.3 Pt or beta radiation applying 1 mgh per square centimeter of lesion.

ERNST A. POHLE, M D, Ph D

Biologic Dosimetry for Radium Preparations. O. Jüngling and H. Langendorff. *Strahlentherapie*, 1933, XLVIII, 174-186.

The radiation emitted from radium preparations was studied with biological methods, for instance, the effect of *Drosophila* eggs. Quite irregular distribution of radio activity over the surface was seen in many instances. To quote one example, three 10-mg gold needles furnished by the same company with the same order showed the following variations. Two had the highest radio-activity at the point of the needle and diminished toward the other end, the third needle, however, had its maximum emission in the center.

ERNST A. POHLE, M D, Ph D

Radium Therapy in Carcinoma of the Lip. Edmund Kelly. *Jour Am Med Assn*, Feb 11, 1933, C, 388-390.

For carcinomas of the lip radium therapy stands pre-eminently as the method of choice. This is an analysis of the cases of 535 patients suffering from carcinoma of the lip for the years 1913 to 1931. The author has taken as representative of the success of irradiation those cases treated during the years 1921-1929, inclusive. Since 1921, an increasing proportion of patients in whom the lesion was still localized or the glandular enlargement moderate has been referred for

radium, also, since that year a more standardized method of application and calculation of dosage has been established. Diagnosis in every case was made by a man experienced in carcinoma of the lip.

The answer to the question as to whether or not radium is an effective treatment for cancer of the lip is that, regardless of allowances, deductions, and comparative statistics, the fact remains that 200 patients with definite carcinoma of the lip, some moderate, some extensive, a few even with glandular metastases, were treated by radium alone, and out of these 200 primary cases there remain 133 patients living and well without recurrence two years after treatment, and of 99 cases treated five years or more ago 72 patients were living and well five years after treatment. The disease is one that is easily recognizable before it has become extensive locally or has metastasized (82 per cent of the primary cases show no palpable metastases), therefore one might reasonably expect to get practically all cases while they are still in the curable stage and by irradiation cure over 90 per cent without hospitalization.

C. G. SUTHERLAND, M. D.

### SCIATICA

The Significance and Treatment of Sciatic Pain  
Winchell McK. Craig and Ralph K. Ghormley Jour  
Am Med Assn., April 15, 1933, C, 1143

From a diagnostic standpoint one should consider constitutional or systemic disease conditions such as diabetes, syphilis, and gout, and the forms of toxic neuritis which develop secondary to absorption of lead, arsenic, or alcohol. Tumors of the spinal cord have been known to cause unilateral pain for many years before the development of additional symptoms which would indicate the diagnosis. Bilateral sciatic pain or a condition in which pain is severe enough to require morphine, suggests tumor of the spinal cord or meninges. Neurofibromas along the course of the sciatic nerve may give rise to sciatic pain. Metastatic or primary tumors pressing on the lumbosacral plexus may have as their initial symptoms unilateral sciatic pain. A sciatic syndrome occasionally develops in certain vascular diseases. Various observers suggest that idiopathic or primary sciatica is caused by inflammatory reactions about the roots which go to form the sciatic nerve, and that sciatica is due to arthritis of the spinal column involving the nerves traversing the foramina or distal to the ganglions. Anomalies of the spinous processes and laminae and *spina bifida occulta* are rarely the cause of sciatic pain. Anomalies of the articular facets may often be contributory factors. Lumbosacral strain or arthritis with changes in the articular facets or in the lumbosacral intervertebral discs may be a causative factor particularly in the lower lumbar region. The fact that sciatic pain does occur in sacroiliac conditions must be accepted although it cannot as yet be explained satisfactorily. A comprehensive review of the methods of treatment follows.

C. G. SUTHERLAND, M. D.

### THE SKULL (DIAGNOSIS)

The Formation of Osteophytes in the Skull and Their Practical Significance F. Leeser, B. Osterlag and A. Horwitz Röntgenpraxis May, 1933 V, 331-335

Osteophytes are osseous outgrowths on the internal aspect of the skull in the region of the frontal bone. The etiologic factors are not known. They are well known to pathologists and have been found in 43 per cent of autopsy material (Dressler). The formation of osteophytes takes place usually in advanced age—in the average case at 70 years. The female sex shows them much more often than does the male. For roentgenologic demonstration occipitofrontal and lateral roentgenograms (preferably stereograms) are necessary. One may see irregular, sometimes fairly well circumscribed areas of increased density, on the internal aspect of the frontal bone which may be rather extensive and of nodular type. Calcification or ossification of the falx may be misleading in lateral roentgenograms, but an postero-anterior film allows the differentiation. Another type is characterized by its map-like symmetrical appearance. On the lateral view one can recognize a dense homogeneous shadow which protrudes considerably in connection with the convexity of the frontal bone. The occipitofrontal view is typical. One sees usually symmetrical, cloud-like, overlapping areas of increased density in the region of both frontal bones. From a differential diagnostic standpoint, tumors of the dura with calcification, calcifying endotheliomas, psammomas, gummas, etc., must be considered, but homogeneity, situation, and sharp limitation of the osteophytes usually permit a correct interpretation. Osteitis fibrosa localisata is less sharply defined and shows areas of bone absorption with areas of bone apposition. Moreover the entire bone (also the external table) is attacked. Osteomas originate in the tabula externa and are unilateral. Clinically, formation of osteophytes is of no significance, however, their recognition is important for diagnostic reasons.

H. W. HEFKE, M. D.

### THE SPINE

Vertebral Epiphysitis and Osteochondritis Paul O. Snoke Jour Bone and Joint Surg., October 1933 XV, 963-968

The author reviews the writings of Scheuermann and Schmorl and presents three cases of dorsal kyphosis classified as follows: One case of true vertebral epiphysitis, one case of osteochondritis and one case of vertebral epiphysitis associated with severe osteochondritis.

Some confusion exists relative to these conditions. While Scheuermann is a clinician, Schmorl is a pathologist and the author believes that Schmorl saw the termination of the disease. Scheuermann described. There is also a possibility that three or more separate diseases or manifestations of the same condition may exist. Evans suggested the following pathologic entities: (1) Vertebral epiphysitis (Scheuermann) (2)

osteochondritis of cartilaginous interface (Schmorl), (3) a combination of these two

The author's paper is illustrated by roentgenograms from the three cases he reports

J N ANÉ, M D

**Prespondylolisthesis Its Roentgenographic Appearance and Clinical Significance** Samuel Kleinberg *Jour Bone and Joint Surg*, October, 1933, XV, 872-881

In the study of congenital lesions of the spine which are known to be important etiologic factors in disturbances and disability of the lumbosacral area, the author believes that prespondylolisthesis also should be considered as a possibility. This condition may be described as a congenital bilateral laminar defect of the last lumbar vertebra without displacement of its segments.

The recognition of prespondylolisthesis is important because it has been proved a definite cause of backache and back disability, which by appropriate treatment can be cured, and also because, in the author's opinion, it precedes spondylolisthesis or actual subluxation of the vertebral body. The detection and proper treatment of prespondylolisthesis, therefore, will prevent the occurrence of spondylolisthesis.

Clinically, these patients complain of weakness and low back pain, aggravated by physical activity and relieved by rest and support of the back. Other symptoms noted were stiffness of the back and sciatic pain. Physical examination may reveal lumbar lordosis, and tenderness to pressure at the lumbosacral junction.

The lateral roentgenogram reveals the pathology. This shows a vertical or slightly oblique defect in the pedicles between the articular processes of the last lumbar, separating the body and superior articular processes in front from the inferior articular processes and neural arch posteriorly. There is no displacement of the segments, although the author found exaggeration of the lumbosacral angle in over half of the cases.

The treatment of this condition is surgical and consists of a fusion of the lower three lumbar vertebrae to the sacrum.

J N ANÉ, M D

**The Dark Stripes in the Roentgenograms of Bechterew's Disease** Kurt Ehrlich *Röntgenpraxis*, May, 1933, V, 347-352

If one studies the roentgenograms of a spine affected with Bechterew's disease, one notices two dark longitudinal stripes on both sides in the region of the small vertebral joints. In the advanced stage of the disease another longitudinal stripe is seen—often with interruptions—which represents unquestionably the ossified ligamentum apicum or supraspinale. The other two stripes have been explained by ossification of the ligamenta intertransversaria by Krebs, Fischer and Vontz believe that they are due to an ossification of the ligaments of the intervertebral joints and the ligamenta flava. By pathologic, anatomical, and experimental

studies the author reaches the conclusion that the bony tissue about the diseased joints and on the joint processes becomes denser, superimposed on a film in such a way as to cause a continuous stripe of increased density. Occasionally the ossified ligamentum anterius, situated just in front, tends to increase the density.

H W HEFKE, M D

## THE SPLEEN

**Hereditary Gaucher's Disease** J P Anderson *Jour Am Med Assn*, Sept 23, 1933, CI, 979-981

Gaucher's disease, according to the present conception, may be defined as a non-hereditary congenital familial disease due to a disturbed lipid metabolism, with the production of an abnormal substance (kerasin). This is stored by histocytes of reticulo-endothelial origin, giving rise to the typical Gaucher cell, which is found in all tissues, chiefly the spleen, lymph glands, liver, and bone marrow, in which reticulo endothelium is present. Clinically the disease is characterized by splenomegaly, hepatomegaly, pigmentation of the skin, pinguecula-like thickenings of the ocular conjunctivæ, hemorrhagic diathesis, unique changes in the bones with discrete or confluent rarefactions, leukopenia, anemia of the hypochromic variety, thrombocytopenia, and, in infants, there may be a preponderance of neurologic symptoms. About the only constant symptom is the enlarged spleen. The age of onset or first discovery varies from birth to 32 years. The course may be acute in children, is usually chronic in adults. The condition commonly is slowly progressive, the patient living for 20 years after the disease has been detected. While it is familial, there is no reported transmission from adult to child.

C G SUTHERLAND, M D

## TENDONS

**Stiff, Painful Shoulders, Exclusive of Tuberculosis and Other Infections** Edson B Fowler *Jour Am Med Assn*, Dec 30, 1933, CI, 2106-2109

Rupture of the supraspinatus tendon is apparently the primary exciting cause of most "stiff, painful shoulders," and early recognition, with prompt proper treatment, will bring about much earlier and better end-results. Codman found a complete rupture of the supraspinatus tendon to every twenty shoulders examined and one incomplete rupture to every third shoulder. He believes that virtually every rupture is caused by the contraction of the supraspinatus muscle and that tears are rarely produced by direct trauma.

C G SUTHERLAND, M D

## THE THORAX

**Tuberculous Pericarditis Its Roentgenologic Significance** Karl Kornblum, Samuel Bellet, and Herman W Ostrum *Am Jour Roentgenol and Rad Ther*, February, 1933, XXIX, 203-213

The x-ray diagnosis of tuberculous pericarditis de-

depends upon the demonstration of pericardial pathology (usually in the form of effusion), the demonstration of pericardial adhesions (usually at the base), the demonstration of tuberculous disease in the lungs or elsewhere in the body, and finally the demonstration (upon correlation) of the clinical data compatible with the diagnosis of tuberculous pericarditis. For the demonstration of pericardial adhesions at the base, it is helpful to inject from 300 to 400 c c of air immediately after aspirating the fluid as completely as possible, a procedure which also makes possible a more accurate determination of the heart size. The authors also feel that examination in the erect and recumbent positions will show less change in contour of the cardiac shadow at the base than in the usual case of non-tuberculous pericardial effusion. Tuberculous pericarditis is estimated to occur in 4 per cent of all tuberculous patients. The article is clearly illustrated.

J E HABBE, M D

Roentgen Diagnosis of Interlobar Pleurisy Charles A Waters Internat Clinics, II, Series 43, 195-201

The author discusses the importance of films made tangentially to the various fissures of the lungs and of the lateral view in addition to the routine postero-anterior view of the chest, in the roentgen diagnosis of interlobar pleurisy. He believes that interlobar exudates are far more common than generally suspected, but that when properly used, the roentgen ray seldom fails to reveal the extent and type of the pathologic process.

The fissure in the left lung starts at the hilus, extends upward to the posterior wall, and laterally and anteriorly downward, the direction of its course corresponding roughly to a line drawn from the third thoracic vertebra to the sixth costochondral junction. The portion of the lung which lies above this line is the upper lobe, while that below is the lower lobe. On the right, there is one main fissure and one accessory fissure. While the main fissure runs relatively the same course except that it is a little more vertical, the accessory fissure begins in the main fissure near the posterior border of the lung, in the region of the posterior axillary line, and running horizontally forward cuts the anterior surface of the lung on a level with the fourth costal cartilage. The upper and middle lobes of the right lung correspond to the upper lobe of the left.

Interlobar pleurisy may result from any inflammation of the tissues contiguous to the interlobar pleura, or from extension inward from the free plural cavity of pleural effusions or empyema following pneumonic processes, or pulmonary tuberculosis in adults. The mediastino-interlobar type of pleurisy

which has its origin in the hilus of the lung is most commonly an accompaniment of mediastinal tuberculosis in children but may occur also in adults.

In the ordinary postero-anterior projection of the chest only effusions or fibrosis in the fissure between the upper and middle lobes on the right can be definitely visualized. Effusions in the oblique fissures are often misdiagnosed as consolidations, tuberculous infiltrations, bronchiectases and even early lung tumors. A lateral view will give the desired information only when the pleural thickening or exudate extends beyond the mediastinum toward the chest wall sufficiently far to cast a shadow which can be clearly differentiated from those shadows due to the mediastinal structures. The author advises the use of the fluoroscope to determine the correct position in which the patient should be placed in making the films. Fleischner first called attention to the so-called "*Kreuzhohlstellung*," in which the patient rests with the neck and shoulders against the film in a semi inclined manner and steadies himself by holding to the frame of the support, thereby stretching his abdomen anteriorly and producing a marked concavity of the spine. The exposure is made antero-posteriorly. In this position the plane of the large oblique interlobar spaces approaches the horizontal so that the central ray passes through the entire extent of the fissure in a tangential direction. Illustrations are included demonstrating the position, as well as roentgenograms illustrating its value in the roentgen study of this condition.

The differential diagnosis of many similar conditions will be simplified if it is remembered that exudates and thickenings in the oblique fissure, when viewed in the "*Kreuzhohlstellung*," reveal wedge- or spindle shaped shadows with sharply outlined superior and inferior borders. On the other hand, a pneumonic process, with the exception of complete consolidation of the middle lobe, ceases abruptly at one of the fissures and presents an irregularity at one of its borders. In complete consolidation of the middle lobe the appearance would be a triangular shadow with its base against the chest wall, and subsequent roentgenograms would show rapid alteration. Sharply defined tumors of the middle lobe will prove more difficult to differentiate. The lateral view may prove of some assistance by showing a spindle-shaped shadow which is sharply outlined on all sides, but in which the off shoot of the spindle corresponds to the remaining fibrosed fissure.

The author believes that these interlobar exudates continue for a very long period of time, and when they are simple effusions, they may eventually be absorbed and leave a residue of thickened pleura.

J N ALCÉ, M D

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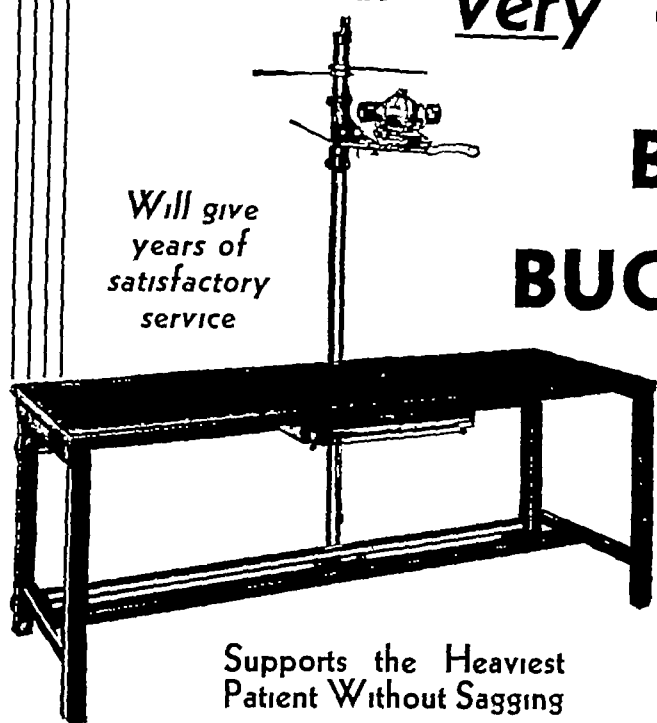


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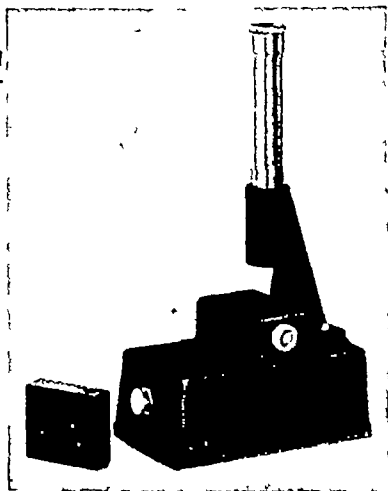
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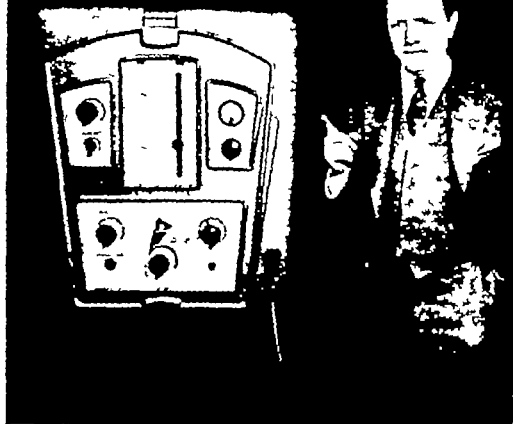
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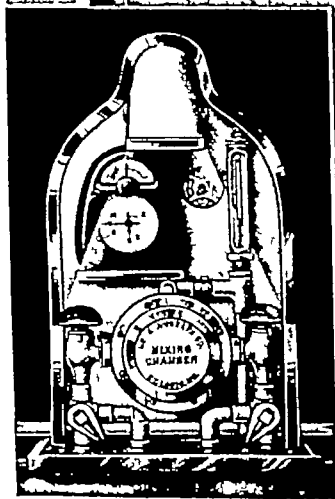
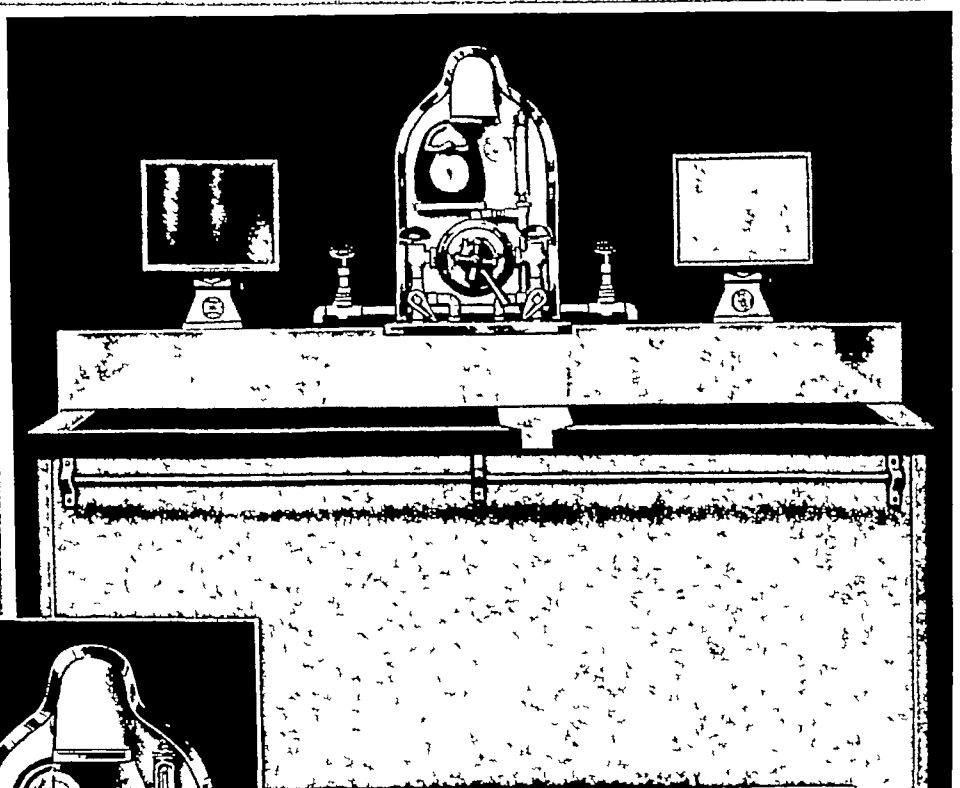
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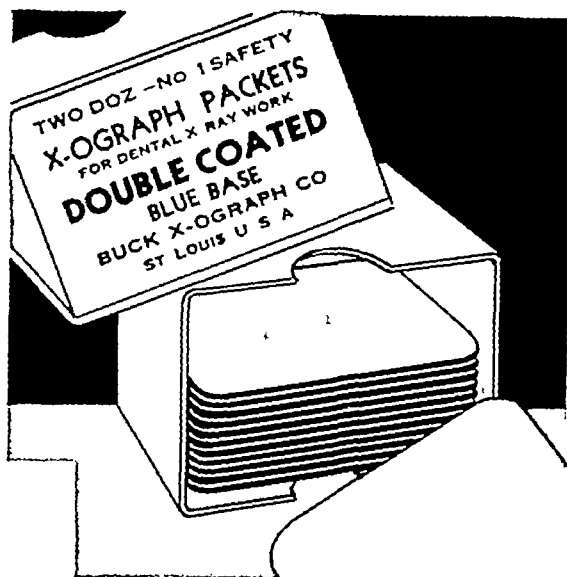


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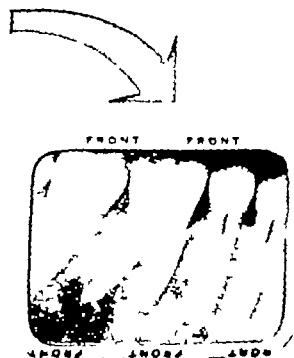
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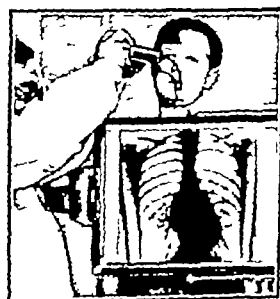
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Composite picture of Dr. Samuel Iglauser demonstrating the intubation method of intrabronchial injection of LIPIODOL, behind the fluoroscopic screen

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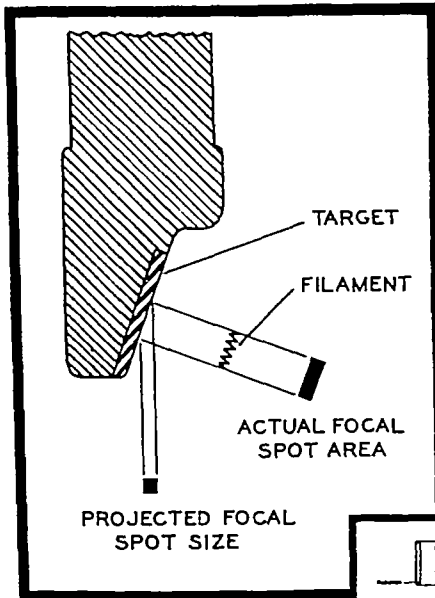
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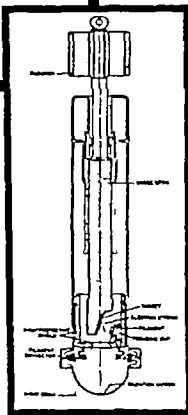
(1) Roentgenogram before injection. Appearance practically normal. (2) Same after Lipiodol injection. Bronchiectatic abscess in right lower lobe previously invisible. Photos courtesy Dr. David H. Ballou, Montreal



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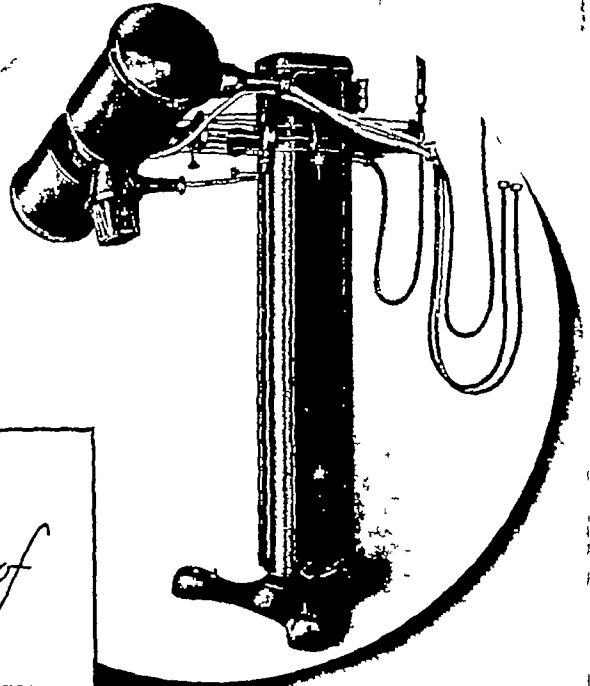
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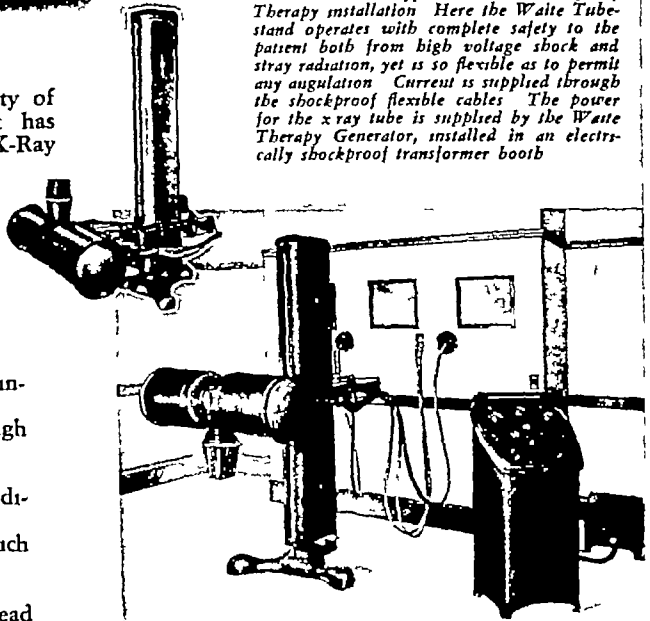
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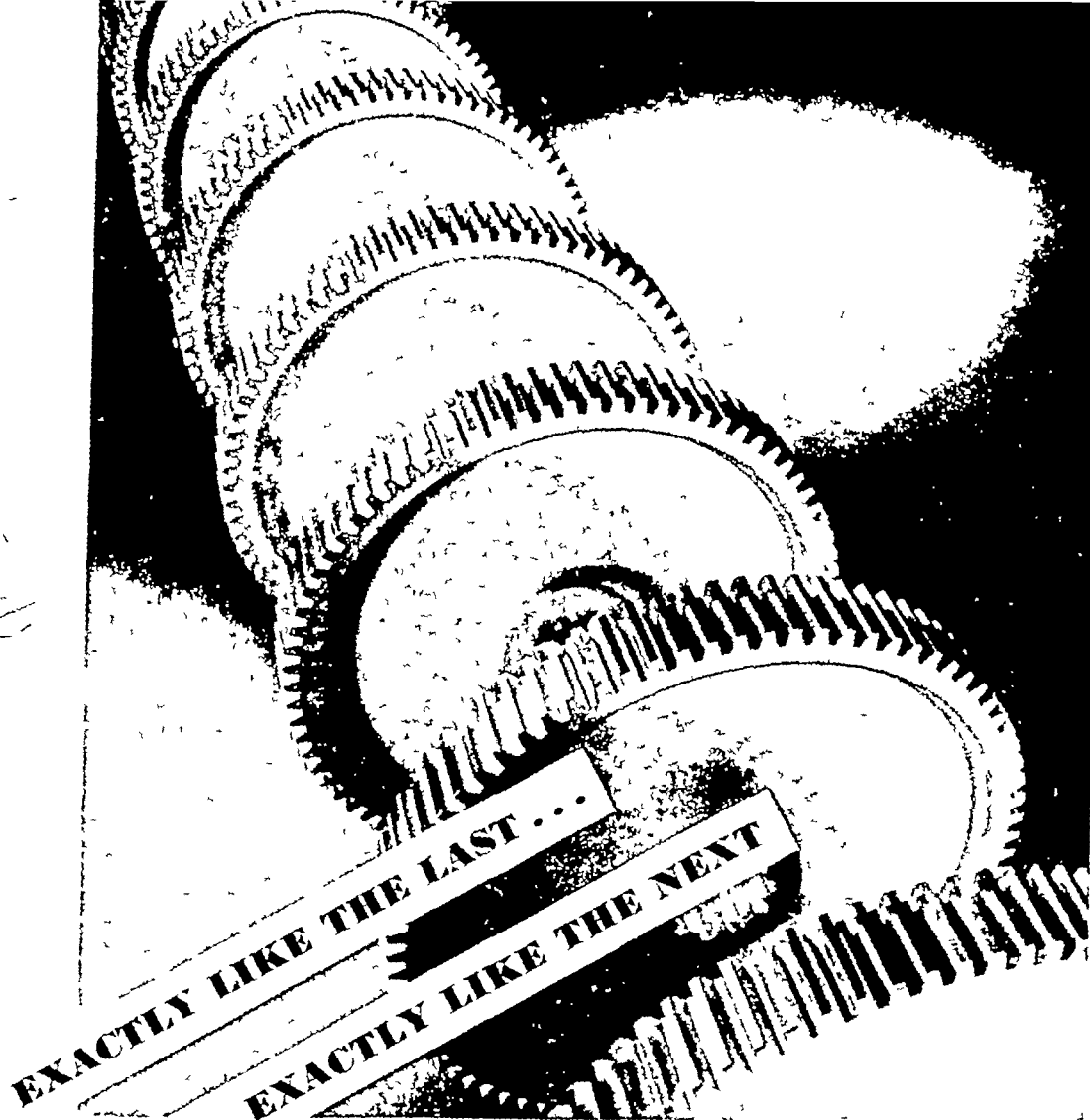
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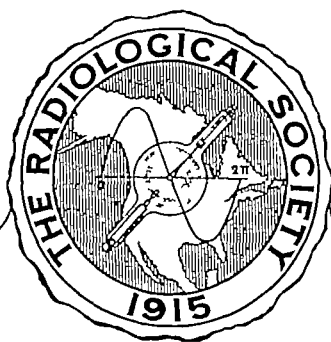


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VOL. XXII

FEBRUARY, 1934

No. 2

## THE VALUE OF THE MENISCUS SIGN IN THE ROENTGENOLOGIC DIAGNOSIS OF ULCERATING GASTRIC CARCINOMA<sup>1</sup>

By B. R. KIRKLIN, M.D., *Rochester, Minnesota*

Section on Roentgenology, The Mayo Clinic

WITH improved apparatus, advances in technic, and information easily to be gained from the recorded experience of his co-workers, the roentgenologist is now properly expected to examine the stomach with almost the same precision as that possible with direct vision and to find the most minute lesions. He is, likewise, expected to carry his differential diagnosis constantly farther, and especially to distinguish benign from malignant disease with a closer approach to accuracy. In view of the importance of this particular distinction, I wish to direct attention to a differential sign which is usually reliable.

In 1921 Carman described a new roentgenologic sign of ulcerating carcinoma of the stomach, a concavo-convex shadow representing the ulcer crater, which he termed "the meniscus sign." Prior to this, Viennese roentgenologists had pointed out that in ulcerating carcinoma the cavity produced by the ulceration is usually situated well within the normal confines of the gastric lumen, and thus contrasts with the crater of a benign ulcer, which is sculptured as a niche in the gastric wall and invariably projects beyond the normal limit of the lumen. No great stress was laid on this mark of distinction, and the

appearance of the crater itself was not considered, for ordinarily the most striking feature of frankly tumefying carcinoma is the resulting gross defect in the gastric shadow, and the form and situation of the excavation produced by sloughing are scarcely important.

Carman, however, had in mind carcinomas in which the element of tumefaction is much less obvious than that of ulceration and of which the character is less readily recognized. Morphologically, these lesions, although not mere ulcers, are essentially ulcerous rather than tumorous, and unless care is exercised, the roentgenologist may confound them with benign ulcers. The pathologist often can identify them grossly as carcinomas, because they are characterized by slightly elevated, irregular, overhanging borders, uneven floors, and no tendency to perforate the wall. Carman found that these morbid anatomic features can be discerned with the roentgen rays and the entire picture is so definite that he regarded it as pathognomonic.

When the lesion is on or near the lesser curvature in the vertical portion of the stomach the crater is seen roentgenoscopically under palpatory pressure as a crescentic shadow, with its convexity directed outward, and the term "meniscus" aptly applies to it. When the lesion is on the lesser curvature distal to the angular

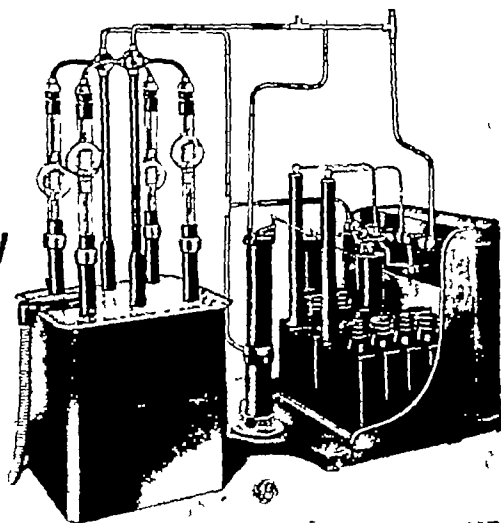
<sup>1</sup> Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, N. J., Nov. 28-Dec. 1, 1932.

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# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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VOL. XXII

FEBRUARY, 1934

No. 2

## THE VALUE OF THE MENISCUS SIGN IN THE ROENTGENOLOGIC DIAGNOSIS OF ULCERATING GASTRIC CARCINOMA<sup>1</sup>

By B R KIRKLIN, M D , *Rochester, Minnesota*

Section on Roentgenology, The Mayo Clinic

WITH improved apparatus, advances in technic, and information easily to be gained from the recorded experience of his co-workers, the roentgenologist is now properly expected to examine the stomach with almost the same precision as that possible with direct vision and to find the most minute lesions. He is, likewise, expected to carry his differential diagnosis constantly farther, and especially to distinguish benign from malignant disease with a closer approach to accuracy. In view of the importance of this particular distinction, I wish to direct attention to a differential sign which is usually reliable.

In 1921 Carman described a new roentgenologic sign of ulcerating carcinoma of the stomach, a concavo-convex shadow representing the ulcer crater, which he termed "the meniscus sign." Prior to this, Viennese roentgenologists had pointed out that in ulcerating carcinoma the cavity produced by the ulceration is usually situated well within the normal confines of the gastric lumen, and thus contrasts with the crater of a benign ulcer, which is sculptured as a niche in the gastric wall and invariably projects beyond the normal limit of the lumen. No great stress was laid on this mark of distinction, and the

appearance of the crater itself was not considered, for ordinarily the most striking feature of frankly tumefying carcinoma is the resulting gross defect in the gastric shadow, and the form and situation of the excavation produced by sloughing are scarcely important.

Carman, however, had in mind carcinomas in which the element of tumefaction is much less obvious than that of ulceration and of which the character is less readily recognized. Morphologically, these lesions, although not mere ulcers, are essentially ulcerous rather than tumorous, and unless care is exercised, the roentgenologist may confound them with benign ulcers. The pathologist often can identify them grossly as carcinomas, because they are characterized by slightly elevated, irregular, overhanging borders, uneven floors, and no tendency to perforate the wall. Carman found that these morbid anatomic features can be discerned with the roentgen rays and the entire picture is so definite that he regarded it as pathognomonic.

When the lesion is on or near the lesser curvature in the vertical portion of the stomach the crater is seen roentgenoscopically under palpatory pressure as a crescentic shadow, with its convexity directed outward, and the term "meniscus" aptly applies to it. When the lesion is on the lesser curvature distal to the angular

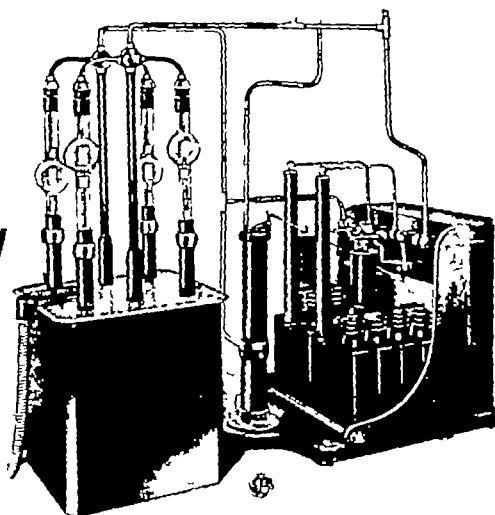
<sup>1</sup> Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, N J, Nov 28-Dec 1, 1932

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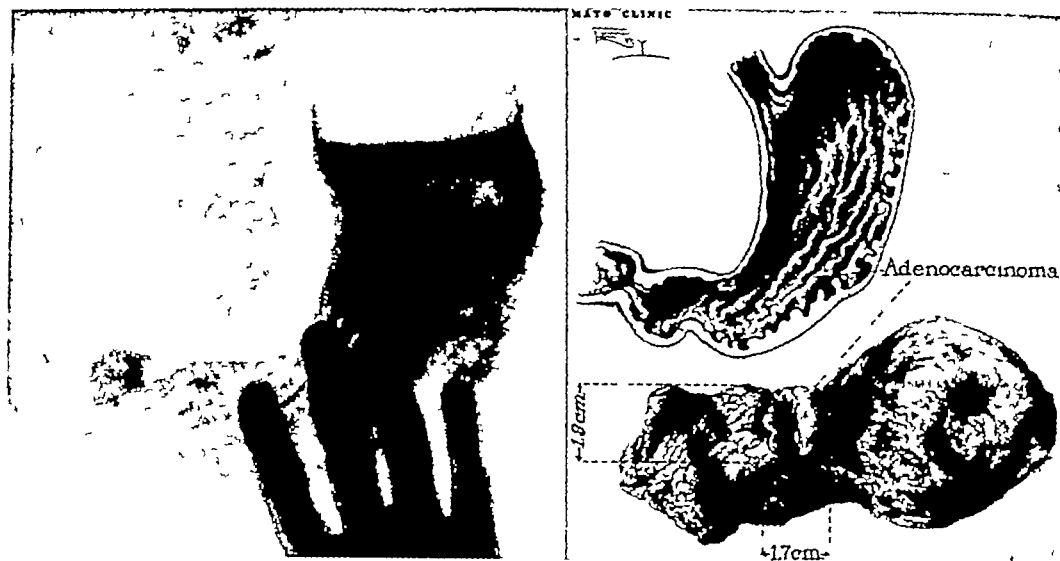
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Figs 1-A and 1-B 1-4 (left), Roentgenoscopic view The meniscus complex on the lesser curvature is seen between the tips of the examiner's index and middle fingers 1-B (right above), Stomach with lesion *in situ* (Right, below), Specimen with lesion

incisura, the base of the crater bends with the wall and the meniscus is concave above. If the ulcer is on the posterior wall, the crater appears, under manual pressure over the stomach, as a dense, irregularly rounded shadow encircled by a transradiant zone which corresponds to the elevated border.

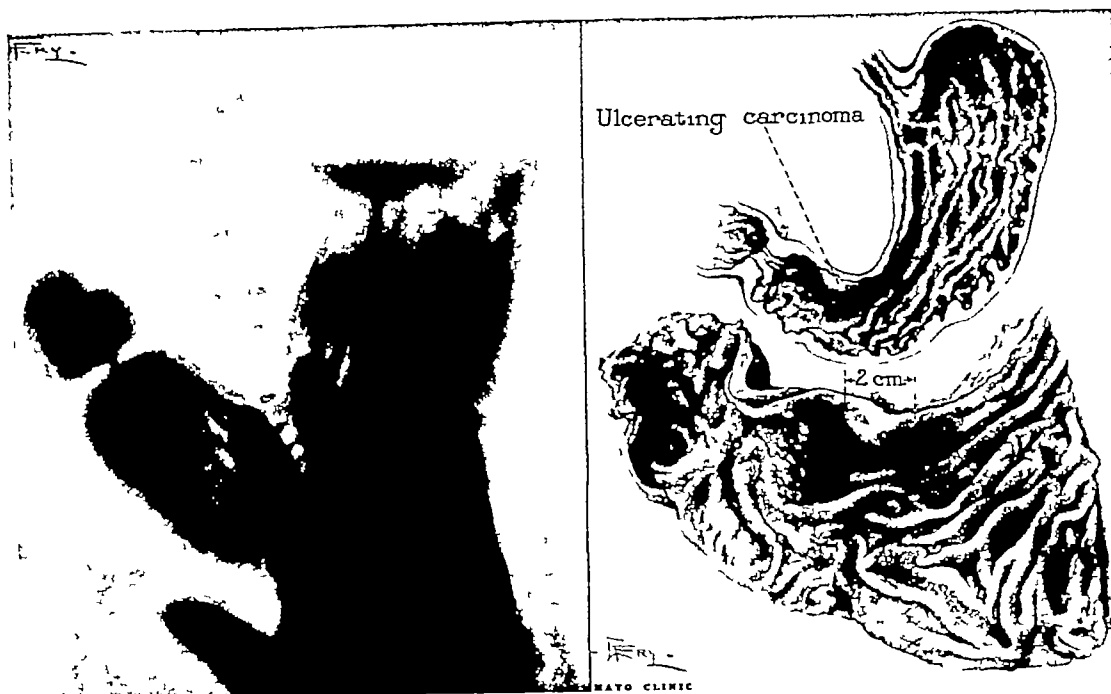
At the Mayo Clinic the diagnostic value of the meniscus with its attendant phenomena has been abundantly proved, and I feel that it is worthy of renewed emphasis. In every surgical case in which these manifestations are elicited an ulcerating carcinoma has been found at operation.

Although the meniscal form of the crater as seen in typical cases is important, it seems to me that the slightly raised, overhanging border is even more significant. When the pressure necessary to demonstrate it is exerted over a lesion of this character on the lesser curvature, the barium-filled crater is separated from the barium in the stomach by a clear zone which represents the approximated overhanging border of the ulcer. Similarly, when the lesion is on the posterior wall, the marginal ridge surrounding the crater is depicted as an encircling transradiant

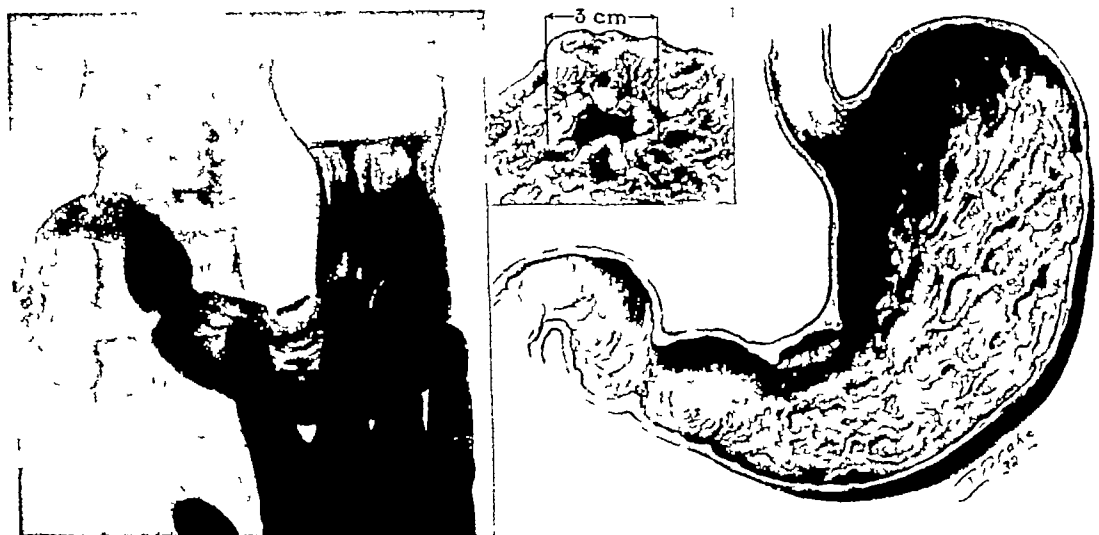
zone. In either instance the zonal defect is quite as striking as the shadowed crater and distinguishes the lesion from benign ulcer, which seldom has a raised or overhanging border. Another mark of the meniscus-crater is its slowness in emptying under pressure, and for this the marginal shelf is also responsible.

Certain other features aid in distinguishing ulcerating gastric carcinoma from simple ulcer. If the crater is visible tangentially as a niche, which is rarely the case, it does not project beyond the normal boundary of the lumen, the rugæ about it are obliterated, not accentuated and convergent as in benign ulcer, occasionally the base of the ulcer has a somewhat irregular profile, in the mesial view a crater on the posterior wall usually has an irregular margin, spastic phenomena are notably absent, the lesion is not tender on pressure, and may be palpable if it is sufficiently large and the abdominal wall is thin and lax.

Ulcerating carcinoma has a decided predilection for the lesser curvature distal to the angular incisura, and on compression the crater often assumes the form of a slit, with its long axis aligned with the



Figs 2-A and 2-B 2-A (left) Roentgenoscopic appearance of meniscus on lesser curvature, almost identical with that shown in Figure 1-A Duodenal bulb deformed by an ulcer 2-B (right, above), Stomach, with ulcerating carcinoma on lesser curvature (Right below), Segment containing lesion



Figs 3-A and 3-B 3-A (left), Roentgenoscopic appearance of meniscus on lesser curvature, somewhat larger than in preceding cases 3-B (right), Ulcerating carcinoma *in situ* and in excised specimen

curvature Barium pent up in a deep sulcus between hypertrophied rugæ has a similar appearance but can easily be dislodged Benign, indurated, saddle-ulcer

on the distal part of the lesser curvature differs from ulcerating carcinoma in that the niche of the former projects prominently and its base is convex above, where-





Fig 4 Meniscus on lesser curvature and, above in insert, resected specimen

as the crater of an ulcerating carcinoma in this situation does not protrude conspicuously, if at all, and its base is concave above

To demonstrate these lesions and determine their character, roentgenoscopic examination under manipulation is indispensable. After the stomach is filled with the mixture of barium the lesions are likely to be concealed so completely that they are not visible in the roentgenogram and sometimes are not readily shown even by compressing the stomach. Accordingly, inspection should begin when the first swallow of barium enters the stomach, and the mixture should be distributed over the gastric walls by palpatory pressure to exhibit the entire mucosal relief. If an abnormality is seen, the patient may be allowed to take additional quantities of barium slowly, if the examiner so desires, but not to distend the stomach. By a downward-stroking pressure of the examiner's hand, the meniscus complex of crater and encircling ridge can be seen clearly above or between the outspread fingers. The complex is demonstrable not only when the lesion is relatively large but also when

they are quite small, as shown by the following cases observed within a year, in all of which the diagnosis rested wholly on this combination of signs

In the first case, that of a man aged 73 years, roentgenoscopic examination revealed a minute meniscus on the lesser curvature, below the angular incisura (Fig 1-A). The diagnosis was small ulcerating carcinoma on the lesser curvature below the angle of the stomach. On surgical exploration the lesion could not be discerned until the lesser peritoneal cavity was opened to permit inspection of the posterior gastric wall. It was seen then as a small, flat growth on the posterior wall near the lesser curvature. Balfour-Polya resection was performed. The pathologist's report was adenocarcinoma graded 2, 1.9 cm by 1.7 cm by 7 mm, with beginning shallow ulceration (Fig 1-B). In his notes, the surgeon stated that the patient had one of the smallest carcinomas that had been diagnosed.

The second patient was a man aged 74 years. On physical examination a firm, nodular, somewhat movable mass about 5 by 15 cm was felt in the upper portion of the abdomen. Roentgenoscopy of the stomach disclosed a very small meniscus on the lesser curvature, at the angle, and definite deformity of the duodenal bulb (Fig 2-A). The diagnosis was early ulcerating carcinoma of the stomach and duodenal ulcer. Neither diagnosis accounted for the palpable mass, and the patient was returned for roentgenoscopy of the colon. This revealed an obstructive lesion near the hepatic flexure, apparently associated with intussusception. On exploration, the surgeon found (1) an invaginated tumor, grossly carcinoma, of the cecum, (2) a duodenal ulcer, and (3) a small tumor, probably malignant, on the lesser curvature 3 inches (7.5 cm) above the pylorus. Hemicolectomy was performed, with the expectation of operating on the stomach later if the patient survived. The cecal tumor proved microscopically to be a papillary adenocarcinoma. Two weeks later the patient died.

of pneumonia. Necropsy confirmed the presence of the duodenal ulcer and the ulcerating gastric carcinoma (Fig 2-B). The latter was 2 by 1.7 cm in dimensions and of the adenomatous variety.

In the third instance, that of a man aged 31 years, the lesion was a shallow ulcer, 1.5 by 3 cm, situated on the lesser curvature just below the angle. In consideration of the meniscus sign, the roentgenologic diagnosis was ulcerating carcinoma (Figs 3-A and 3-B). At operation, the surgeon found it difficult to believe that the lesion was other than a simple ulcer with an inflammatory zone about it, from macroscopic inspection the pathologist likewise inclined to the opinion that it was not malignant (Fig 3-B). Microscopically it proved to be adenocarcinoma.

The fourth patient was a man aged 70 years. On roentgenologic examination a small meniscus was apparent on the lesser curvature, slightly distal to the angle, and the diagnosis accordingly was ulcerating carcinoma (Fig 4). When excised by the surgeon, the lesion, which was 1 cm in diameter, had the appearance grossly of a benign ulcer, but microscopically it was found to be an adenocarcinoma graded 3.

In each of these cases the meniscus was so small that it would not have been demonstrable without close adherence to a routine roentgenoscopic technic. Even when the

lesions are considerably larger, careful and methodical examination is requisite to disclose them. Especially necessary are three technical features, namely, to begin roentgenoscopic inspection when the first swallow of barium is taken, to distribute the bolus of barium and its successors over the wall of the stomach by manipulation, and to study the internal gastric relief while it is being revealed by downward stroking pressure of the examiner's fingers. To accomplish these maneuvers successfully it is imperative that the patient's abdominal wall be completely relaxed. Critical examination of the internal surface of the stomach was introduced long ago by Holzknecht and is widely employed. Observance of this detail apparently has not been universal, however, for roentgenography of the mucosal relief, now being emphasized by European roentgenologists, has been regarded by many as fundamentally new. Roentgenograms for permanent record are often desirable, but roentgenoscopic scrutiny of the gastric internal topography is basic, and the most trustworthy method of discovering narrowly limited organic changes.

#### REFERENCE

- (1) CARMAN R. D., New Roentgen-ray Sign of Ulcerating Gastric Cancer. Jour Am Med Assn., Sept 24 1921, LXXVII, 990-992.

# CARCINOMA OF THE LIP AND MOUTH<sup>1</sup>

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THE literature produced by the larger cancer centers allots a rôle of ever-increasing importance to irradiation in the treatment of lesions in and about the mouth, but the average practitioner of medicine, whose judgment is based on his personal experience, is in most instances quite unconvinced of its value. Nor is he always to be condemned for his attitude, since his radiological confrères, especially those located at a distance from the large cities, are too frequently inclined to use inefficient methods, assuming perhaps that they cannot afford to equip themselves with the necessary apparatus needed for better results.

It is the author's opinion that quite creditable work may be done with equipment of modest proportions, and this article is written in an effort to stimulate the interest of those radiotherapists who are not connected with large, richly endowed institutions. Their good work, displayed before their medical colleagues, will mold medical opinion as no amount of writing can possibly do.

Carcinomas of the lip, mouth, and pharynx are, with few exceptions, of the squamous-cell variety, and, generally speaking, it may be stated that efficient treatment must be designed to take care of that kind of malignancy. Experimental work and clinical observation have evolved certain principles which should, when possible, be followed. They are:

1 Six to twelve erythema doses of irradiation are needed for the actual cure of squamous-cell carcinoma.

2 Recovery is more rapid and surrounding normal tissues show a quicker return to normal when the treatment is administered over a prolonged period, usually from seven to fourteen days.

3 Short wave lengths produced by heavy filtration lessen the injury to surrounding normal tissues but are not essential in treating superficial lesions on the lip.

4 An attempt should always be made to produce a cure with the first series of treatments, since the second attempt is never so successful and may produce injurious effects.

5 Infection and irritation (tobacco, bad teeth, etc.) interfere with healing and must be eliminated during treatment.

Since the therapy accorded primary lesions is quite different from that used for metastases in the neck, the first portion of this paper will deal entirely with the primary conditions and the management of the neck will be taken up later.

## CANCER OF THE LIP

Carcinoma of the lip is an accessible, easily recognized lesion which metastasizes very late. Any method of treatment which thoroughly eradicates the primary lesion will, therefore, produce a large number of cures, and the surgical statistics are universally good. However, both x-rays alone and radium alone have, in the hands of those therapists possessed of enough courage to give ample dosage, brought about equally good results. Unfortunately almost every surgical clinic has seen many cases treated by the over-cautious radiologist who slowly feels his way along, giving one or two erythema doses and then waiting a few weeks to see what happens. After a few months of this therapy the lesion frequently becomes so radioresistant that radiation is no longer effective, and the surgeon who is finally called in cannot understand why he was not consulted in the beginning. This conservative attitude in radiation therapy has

<sup>1</sup> Presented before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

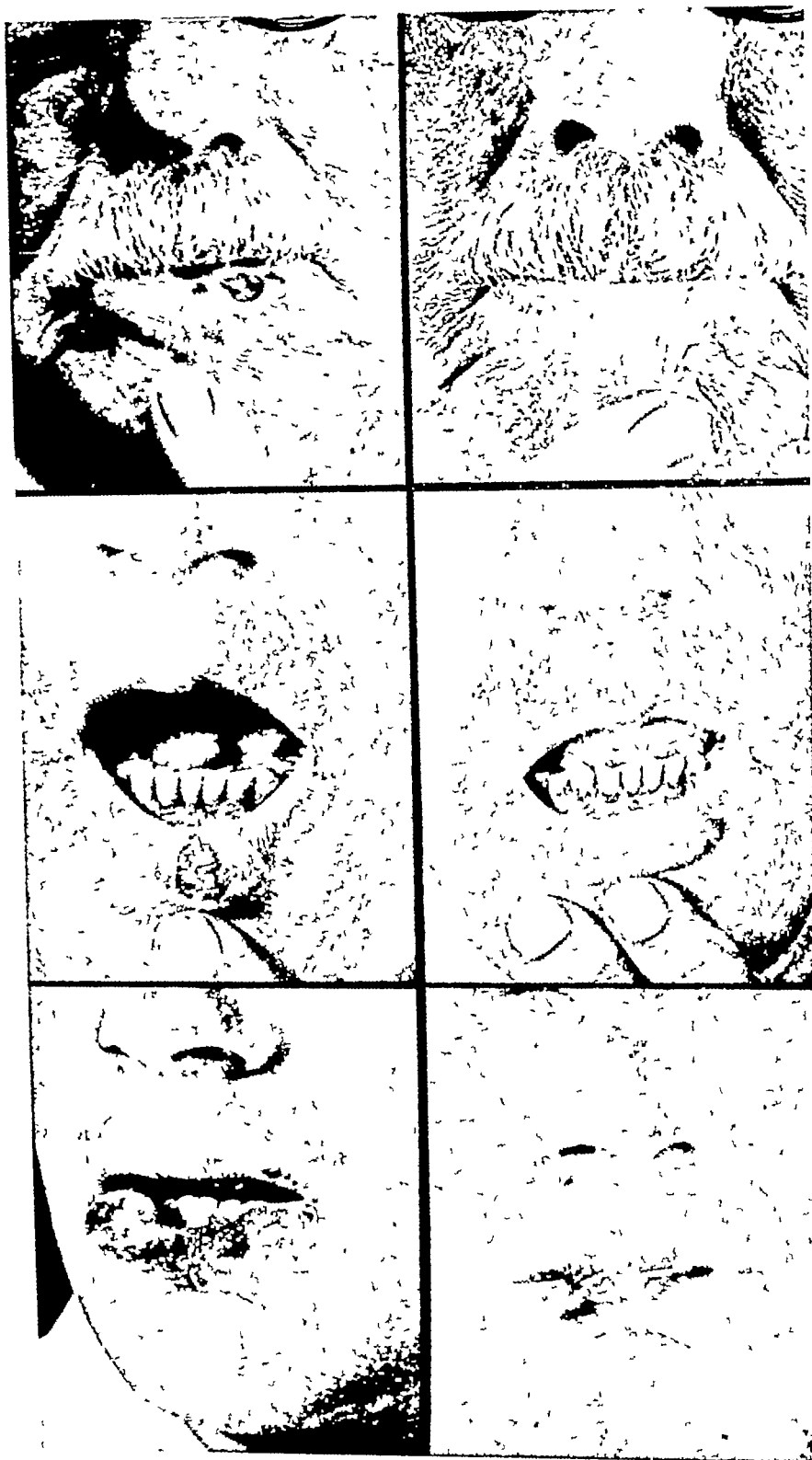


Fig 1 Cancers of the lower lip, all of which have remained well for three years or more Treatment consisted of x-rays alone in each instance

been sponsored largely by the dermatological literature, which, almost without exception, recommends doses that are entirely too small to produce a cure

Most carcinomas of the lip which do not extend into the mucous membrane of the cheek and which have not been treated previously with radiation, respond quite satisfactorily to from six to twelve minimum erythema doses of long wave length x-rays. The cosmetic results are very good indeed and the method is an economical one, since neither hospitalization nor expensive radium applicators are necessary. This technic was developed by Pusey (1) more than twenty years ago, but for some reason it has never come into general use.

Our plan of treatment has been published in previous articles (2, 3, 4) and will not be elaborated here. Suffice it to say that one or two erythema doses of lightly filtered x-rays generated at a low voltage are administered to the lesion and immediately adjoining tissues every day or every other day until from six to twelve erythema doses have been given. A marked reaction occurs but complete healing usually is obtained in from six to eight weeks. In 1931, statistics were published covering 119 traced cases treated from 1906 to 1925. Eleven of these patients had glands in the neck at the time of treatment and they are all dead. This leaves 108 cases that had no palpable glands at the time of treatment. Of this group, 104 have remained well without visible evidence of the disease for five years or longer—many have been well for more than ten years and one for thirteen years. The four that died had definite recurrences in the glands. In this series, then, 96.3 per cent of the patients without demonstrable extension into the lymphatic system have remained well for five years or longer.

A recent survey of a similar group treated from 1925 to 1928 shows 41 patients out of 42 alive at the end of five years, one dying of a recurrence in the glands of the neck. Two cases in this series had stubborn local recurrences which were treated

surgically, with good results. It is only fair to say that most of the lesions in this latter survey were of moderate size and, therefore, favorable for treatment. This may be attributed to the fact that the radiologic method has become well known in our vicinity as a simple procedure which usually cures cancer of the lip without operative interference. Watchful waiting is never so frequent when the proposed treatment is non-surgical.

Exception is frequently taken to our statistics because, in most instances, no histologic studies are made. The clinical diagnosis of carcinoma of the lip is a relatively easy one to make and those who have viewed our patients or their photographs rarely question the diagnosis. It is our feeling that the best cosmetic results cannot be obtained, particularly in small lesions, when tissue is removed, and since the biopsy may also favor metastases the procedure is usually omitted in lip cases. The rapid disappearance of the tumor under treatment is in itself a valuable diagnostic test, since benign lesions do not as a rule show this response.

Lip lesions which previously have been subjected to a long series of ineffective x-ray treatments do not receive the technic just described. When there is no visible irradiation effect or the reaction is of a moderate degree weak radium needles are implanted under the edges of the tumor for a period of seven days. This technic will be described in detail under the heading of Intra-oral Carcinoma. It requires hospitalization and may produce some scarring, but it is usually quite effective. When the treated area shows a smoldering treatment reaction which has not healed in a reasonable period, radical excision of the involved region offers the best chance of a good result.

Carcinomas arising on one side of the lip sometimes extend out onto the mucous membrane lining the cheek and involve the corner of the mouth in such a manner that the x-ray cone cannot be applied directly to all the lesion. In such cases weak radium needles are sewed under the

edges of the inaccessible portions of the tumor for a period of seven days, while the accessible portion is treated with the regular x-ray technic. This combined plan has proved quite satisfactory in that it produces little deformity of the corner of the mouth and the mucous membrane is restored to a practically normal condition.

#### INTRA-ORAL CARCINOMA

Intra-oral carcinoma is a much more difficult problem than lip carcinoma, because metastases of a stubborn type occur quite early. No plan of treatment has yielded a high percentage of cures, but radiation has become the method of choice in hospitals where it is available, because of its relative simplicity and the good cosmetic results which it frequently yields.

Radiologists are all familiar with the good work done by Quick and his co-workers at the Memorial Hospital with gold radon seeds. However, these implants are immediately available in only a few centers outside of New York City and in most localities they must be ordered from New York if they are to be obtained at all. A worthy substitute is, therefore, highly desirable in the more distant communities.

Regaud (5) has, during the past ten years, advocated the use of heavily filtered platinum radium element needles of low intensity for intra-oral malignancies, and his technic has been further elaborated by Cade (6), Ward and Smith (7), Birkett (8), and others in London hospitals. This method has certain disadvantages in that it necessitates hospitalization for seven or eight days, and it cannot be used in regions which are difficult of access such as the posterior nasopharynx, where radon seeds may be placed with specially constructed trocars. However, it is an efficient, relatively economical procedure which reduces sloughing and secondary reactions to a minimum, and it may be carried out in any standard operating room.

Our needles are all constructed of platinum-iridium and have wall thicknesses of 0.5 and 0.6 millimeter. There are three different sizes which have active lengths of 1, 2, and 4 cm, respectively, and the radium element is evenly distributed throughout each needle so that there is 0.6 mg contained in each centimeter of active length. This method of loading was adopted after it was found that 0.6 mg of radium in a 1.0 cm needle could destroy 1.0 cubic centimeter of squamous-cell carcinoma when it was centrally placed for a period of seven days. In effecting implantations an effort is always made to insert the needles beneath and around the edges of the tumor so that they are spaced about 1 cm apart. They may be placed radially or in parallel patterns, and in intra-oral work each needle must be stitched in place so that it cannot be lost or slipped out of position.

The details of the technic were given in a previous article (9). When a large mass occurs in the cheek, it is wise to sew a row of small needles around the edges of the tumor within the mouth and insert a series of long needles under the growth from an external approach. This carries out the general plan of thoroughly radiating the tumor bed and its growing edges, which apparently accounts for the success of the needle technic. Such a plan is more difficult of execution when the lesion appears in the tongue or floor of the mouth, but the attack is always aimed at the tissues surrounding the neoplasm when possible.

After the implantation is completed radiographs are made and the needle patterns are studied. If the distribution of the sources of radiant energy is not quite what it should be, a readjustment is made. Since success depends on a good pattern this procedure is a most valuable one. Perhaps the greatest disadvantage of radon seeds is the fact that they cannot be readjusted after they are once inserted into the tumor. It is also found rather difficult to place these tiny structures with the precision that can be attained with

the needles, the location of which is indicated by anchor stitches

During the time that the radium remains in place the patient stays in the hospital, although he is usually not confined to bed for more than one or two days. A rigid system of oral hygiene is observed,

the mouth being washed out frequently with antiseptic solutions. The involved region is also painted at least three times daily with 2 per cent mercurochrome. The diet consists for the most part of a liquid 2,000-calorie formula, augmented at intervals with small amounts of fruit



Fig 2 Squamous-cell carcinoma of lower lip insufficiently treated with x rays. Healing was obtained with weak radium needles but the cosmetic result was not so good as that obtained with x rays

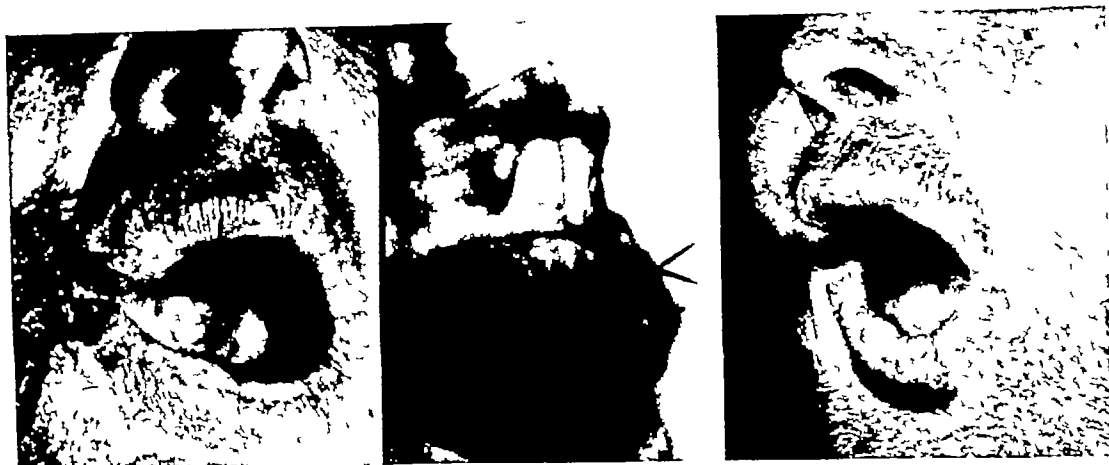


Fig 3 Carcinoma involving corner of the mouth. The external lesion was treated with x-rays and weak radium needles were used in the corner of the mouth with the result shown on the right

juice. Although codeine is ordered for all cases it is rarely needed after the second or third day.

At the end of seven days, when the anchor stitches are clipped and the needles are removed, some shrinkage of the tumor is frequently seen. After about two weeks the mucous membrane in the treated region takes on a grayish color. Although at first glance a slough appears to be forming, such is not really the case, because the reaction is limited to the superficial layers and is not accompanied by pain. In another two or three weeks the grayish membrane comes away, leaving pink granulation tissue beneath, and rapid healing usually follows. When the primary lesion is of moderate size the whole process requires about two months. Practically no scarring is observed when the tumor is small, and when scars do result they are soft and pliable and give little trouble afterward.

Many of the early workers constructed cumbersome lead shields which were worn in the mouth to protect the bony structures from the effect of the rays. We have found this precaution unnecessary and have on a number of occasions planted 0.6 mg needles against the alveolar margins and the hard palate for seven days without producing necrosis in the bone. Hard palate implantations will invariably pro-

duce a superficial reaction on the tongue unless some protective apparatus is used, but these reactions heal readily, leaving little evidence of their presence.

Since this work was started in our laboratory in a very limited way about three years ago we have no three-to five-year statistics available. However, a brief survey of our material may be of some interest. Our cases have been unselected and represent a rather unfavorable group, coming for the most part from the rural districts. Forty such patients have been treated, but three of them can no longer be located, leaving a group of 37 that have been traced. Thirty of these cases were treated more than one year ago and a study of their progress is of some value. The primary lesions varied from one-half to three inches in diameter, but only two measured less than three-quarters inch in diameter, and twenty measured one inch or more in diameter. Sixteen, or about half of the patients, had palpable lymph nodes in the neck at the time that treatment was instituted. Histologic studies showing squamous-cell carcinoma to be present were made in all of the cases except two, but the clinical diagnosis seemed evident in each instance. The pathologic department at Baylor University Hospital graded most of the tumors as I or II, but a few Grade III neoplasms were en-



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Fig 5 Grade I squamous-cell carcinoma of the cheek treated with weak radium needles The result on the right indicates that the lower grades respond as well as the higher ones

the histologic grading might be. In fact, some of the Grade I tumors have shown as rapid a regression as any of the others. It is our impression, therefore, that grading is of little value except insofar as it indicates the probability of early metastases or the radiosensitivity of metastases which have already appeared.

One of our greatest problems has been the care of the patient, usually with an advanced lesion, who, several months after treatment, develops a recurrence in the treated area or adjacent to it. In the beginning these cases were again subjected to an extensive radium implantation, but almost without exception this procedure resulted in the formation of a deep slough, which often did not eliminate all of the diseased tissue and the ultimate result was usually most unhappy. If, as many think, primary resolution occurs as a result of the effect of radiation on the young blood vessels entering the malignant tissue, a second heavy dose may completely obliterate the blood supply, and this is what apparently happens. In one such case the side of the cheek and a large part of the neck fell away, leaving the mandible exposed. There was surprisingly little pain, and no evidence of carcinoma can be detected at the end of a year. However, this good result was exceptional and secondary implantations should most cer-

tainly be avoided when possible. For this reason the first needle pattern must be laid out with meticulous care so that the greatest possible regression may be obtained from it.

#### CARCINOMA OF THE PHARYNX

Mention has already been made of the difficulty encountered in using radium needles in the posterior portion of the mouth and in the pharynx. Fortunately, tumors located in these regions are as a rule quite radiosensitive. Martin and Pflueger (10) have recently shown that pharyngeal tumors are much more sensitive to radiation than their grading would indicate, and in some cases complete though temporary regression followed the administration of less than two erythema doses into the lesions. However these same authors advocate a minimum of six erythema doses for the production of an actual cure.

External radiation is obviously more likely to be successful in cases in which the malignant tissue is not deeply situated and is quite radiosensitive, and Coutard's (11) good results in pharyngeal tumors (obtained with his massive divided dose x-ray technique) are, therefore, not surprising. Since his doses are given in terms of the amount striking the skin, an

countered. The primary lesions disappeared in all except two patients. One was an old, anemic man with a hard, deep ulcer in the cheek, the other a man who used tobacco and alcohol excessively soon after the treatment was given. Seventeen of the cases (56 per cent) have been alive for more than one year, and

twelve (40 per cent) have shown no evidence of carcinoma for a year or more. Two of this latter group, one a carcinoma of the tongue and the other a carcinoma of the cheek, have remained well for a little more than three years.

The primary lesions have responded to treatment equally well, regardless of what



Fig. 4. Squamous-cell carcinoma of the cheek and alveolar margin with a perforation through the cheek. Small needles were placed around the lesion and long needles were embedded in the cheek. The excellent internal and external results are shown below.

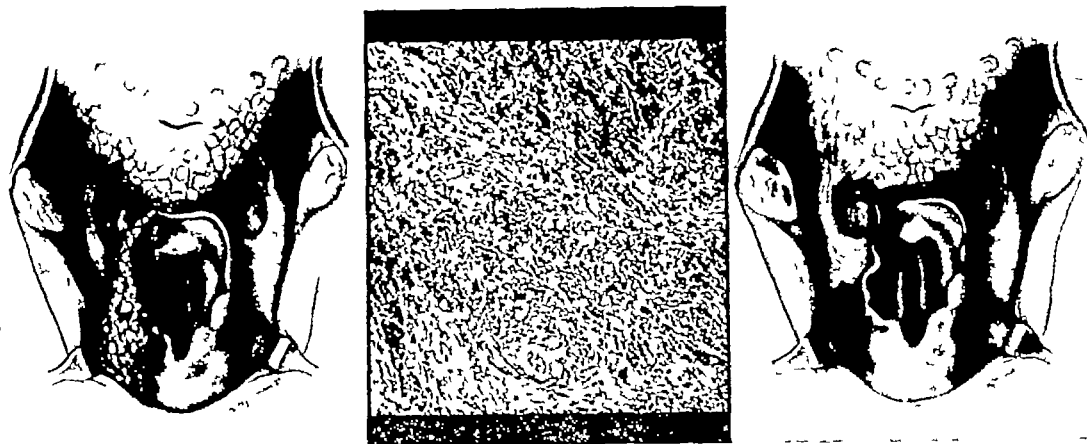


Fig 7 Squamous cell carcinoma Grade III involving larynx and pharynx. The result on the right was obtained by applying ten half erythema doses of deep x-rays to the left side of the neck on successive days

having palpable nodes that are considered operable, and those having inoperable metastases in the neck

The first group is the one over which most controversy arises. The surgeon who observes that a large number of the patients of this type who have block dissections get well is quite certain that a routine block should be done in every case. This attitude cannot be shaken, even though it has been shown that in most instances the material removed contains no malignant tissue. If this routine is to be adopted, it should be reserved for the intra-oral lesions, which usually involve the lymph nodes quite early. Carcinoma of the lip spreads to the lymphatic system at a much later stage of the disease and should, in our opinion, be handled in a more conservative manner. Our statistics (12), as well as those of Duffy (13), indicate that the number of cures obtained equals that accredited to the most radical surgical procedures, and the patients not only avoid the inconvenience of the operation but are not subjected to its added risks—a small factor but still worth considering. It is our custom to administer heavy external irradiation to the neck with deep x-rays and radium packs at the same time that the primary lesion is treated. The dosage is sufficient to cause a marked desquamation of the superficial layers of the skin. The

patient is warned about the significance of enlarged cervical nodes and is asked to report back immediately upon discovering glands in the neck. When they appear later, and this is a rare occurrence in lip cases, a block dissection is recommended.

When the neck contains operable malignant lymph nodes at the patient's first visit, operation is advised. In this class of patients a difference of opinion frequently arises over what constitutes an operable case. Quick's (14) criteria are based on an ample experience and may be used as a guide. He considers that a case is operable which has a few freely movable glands that show no evidence of extension, have not broken through their capsules, and are situated on one side of the neck only. Patients having numerous glands, glands attached to underlying structures, and glands on both sides of the neck are not considered operable. When, at the time of operation, the surgeon feels that he may be leaving malignant tissue behind, radon implants or small platinum radium needles may be used in the suspicious regions. Of course, such cases are not really operable in the beginning, but in borderline cases it is sometimes difficult to accurately determine operability.

The inoperable cervical nodes are a radiological problem though not a very hopeful one. Although many radiologists

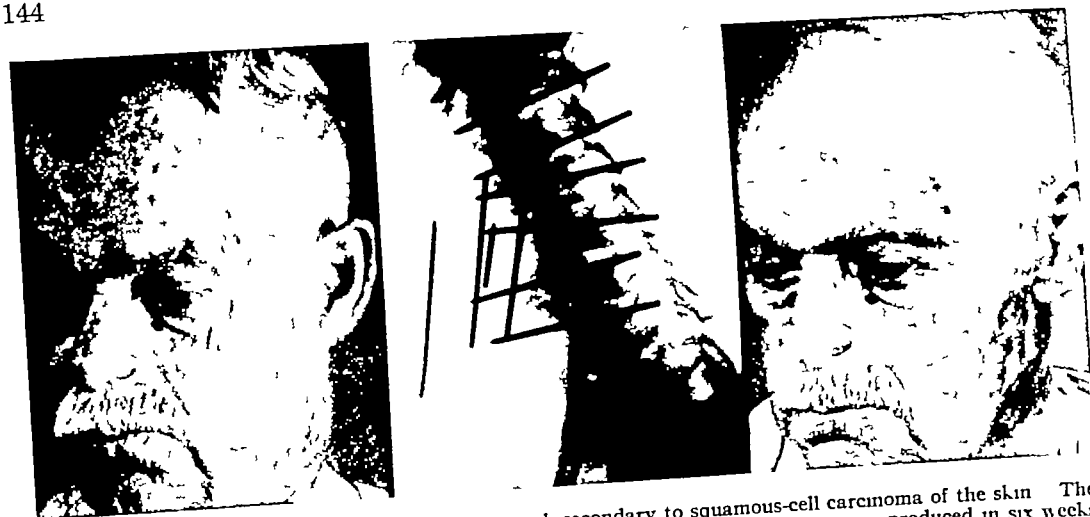


Fig 6 Large mass of malignant glands in neck secondary to squamous-cell carcinoma of the skin The embedding of long weak radium needles together with radium packs and deep x rays produced in six weeks the appearance shown on the right

estimation of his depth doses cannot be accurately made, but his results indicate that they are ample. Although his technique can be carried out in any laboratory equipped for deep therapy, it is a most time-consuming procedure and, therefore, not economical. In an effort to produce palliation in pharyngeal tumors we have, during the past year, used the Coutard plan with a filter of 0.75 mm of copper and 1 mm of aluminum, thereby cutting down the total treatment time appreciably. One-half erythema dose is given over the same area on the neck daily until ten or twelve such doses have been administered. In two to three weeks the neck shows a marked desquamation but no ulceration, and it seems evident that this dose might be safely increased. A patient having an extensive squamous-cell carcinoma involving one-half of the epiglottis and the side of the pharynx and larynx has remained apparently well for four months following this procedure. All visible evidence of the disease completely disappeared in two weeks, leaving the mucous membrane pink and healthy in appearance. Although this modified technique may not be curative it has a place in a busy clinic where an effort is made to do something for all types of patients.

#### CERVICAL ADENOPATHY

The outlook for patients with cancer in and about the mouth might be said to be most favorable now if some thoroughly efficient method of controlling metastases in the cervical lymph nodes could be devised. Various radical block operations have been elaborated, but the fact remains that striking success has been accredited to these procedures only in the cases in which no malignant invasion has yet appeared in the lymphatic system. It must be admitted, however, that a certain small number of favorable cases with cancer in the cervical lymph nodes have been cured by operation, whereas statistics claiming cures from radiation alone are indeed rare. The mechanism by means of which the regression of carcinoma in a lymph node is brought about seems to be quite different from that which operates in the primary lesion, probably because of the difference in the arrangement of the blood supply in the tumor bed. Although heavily filtered radiation when delivered in large doses causes the enlarged glands to shrink, recurrences are the rule.

For practical purposes all cases may be divided into three classes, namely, those having no palpable lymph nodes, those



Fig 7 Squamous cell carcinoma Grade III involving larynx and pharynx. The result on the right was obtained by applying ten half erythema doses of deep x-rays to the left side of the neck on successive days

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The first group is the one over which most controversy arises. The surgeon who observes that a large number of the patients of this type who have block dissections get well is quite certain that a routine block should be done in every case. This attitude cannot be shaken, even though it has been shown that in most instances the material removed contains no malignant tissue. If this routine is to be adopted, it should be reserved for the intra-oral lesions, which usually involve the lymph nodes quite early. Carcinoma of the lip spreads to the lymphatic system at a much later stage of the disease and should, in our opinion, be handled in a more conservative manner. Our statistics (12), as well as those of Duffy (13), indicate that the number of cures obtained equals that accredited to the most radical surgical procedures, and the patients not only avoid the inconvenience of the operation but are not subjected to its added risks—a small factor but still worth considering. It is our custom to administer heavy external irradiation to the neck with deep x-rays and radium packs at the same time that the primary lesion is treated. The dosage is sufficient to cause a marked desquamation of the superficial layers of the skin. The

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When the neck contains operable malignant lymph nodes at the patient's first visit, operation is advised. In this class of patients a difference of opinion frequently arises over what constitutes an operable case. Quick's (14) criteria are based on an ample experience and may be used as a guide. He considers that a case is operable which has a few freely movable glands that show no evidence of extension, have not broken through their capsules, and are situated on one side of the neck only. Patients having numerous glands, glands attached to underlying structures, and glands on both sides of the neck are not considered operable. When, at the time of operation, the surgeon feels that he may be leaving malignant tissue behind, radon implants or small platinum radium needles may be used in the suspicious regions. Of course, such cases are not really operable in the beginning, but in borderline cases it is sometimes difficult to accurately determine operability.

The inoperable cervical nodes are a radiological problem though not a very hopeful one. Although many radiologists

are opposed to interstitial radiation for such patients, our best results have been obtained with a combination of external and internal sources. Long platinum needles containing 0.6 mg of radium per centimeter of active length are inserted beneath the involved nodes and well beyond them, at intervals of 1 to 1.5 cm, and left in place for seven days. A 100-mg radium pack, having the radium placed in platinum capsules with 1 mm walls, at a distance of 2 cm from the skin, is then applied to the neck over the involved nodes and left in place for thirty-six hours. In addition, both sides of the neck from the upper jaw to the clavicle are given an erythema dose of x-ray generated at 200 K V and filtered through 0.75 mm of copper and 1.0 mm of aluminum at a 50-cm target-skin distance. This plan produces a marked desquamation of the skin and a few areas may show a temporary superficial ulceration. However, in the course of four to six weeks the reaction subsides, leaving the skin soft and pliable and the malignant glands usually show a marked shrinkage. The patients show definite clinical improvement which may last for from four to six months and occasionally much longer.

#### SUMMARY

Technics are described which should enable a radiotherapist having a standard

x-ray laboratory and a moderate quantity of radium available to produce creditable results in cancer of the lip and mouth.

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# CHRONIC ARTHRITIS OF THE SPINE<sup>1</sup>

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UNDER this title, we include those non-specific arthritides whose origin is in dispute, and whose nomenclature and clinical differentiation have never found universal acceptance. These arthritides are often grouped under the name of "spondylitis deformans," especially those cases which exhibit deformity and various grades of rigidity. "Spondylitis ankylopoietica" is a name which is sometimes applied to those cases whose chief characteristic is ankylosis of the spine, usually due to ligamentous calcification. The etiology of this group is usually attributed to some obscure infectious agent.

We believe that from a study of the clinical features, together with the gross roentgen pathology, one can differentiate these cases still further. The classification given by Knaggs (1) seems to be clear-cut and the terminology bears a direct relation to the underlying pathology. This classification is as follows: I *Spondylitis Ossificans Ligamentosa*—This corresponds to the cases described by Marie and Strumpell and is usually considered as the spinal manifestation of atrophic arthritis, II *Spondylitis Muscularis*—This group is identical with the type described by Von Bechterew, who emphasized the muscular weakness and the nerve changes, III *Spondylitis Osteoarthritis*—The changes in this type represent the type of arthritis that is ordinarily designated as hypertrophic arthritis.

The subject matter of this communication is for the most part old, and we have no original contribution to make. Rather, we have gone back to the original articles of Marie (2) and Von Bechterew (3 and 4), attempting to get their point of view of the conditions that bear their

names and to correlate this with our later knowledge, which is more largely derived from the roentgen examination.

## SPONDYLITIS RHIZOMELIQUE—MARIE-STRUMPELL ARTHRITIS

This type of ankylosing arthritis was first described by Pierre Marie (2) in 1898, who called it "spondylitis rhizomelique" from the Greek words *spondylos*, meaning "vertebra," *rhiza*, meaning "root," and *melos*, meaning "member." The chief characteristics of the disease according to Marie (2) are the coincidence of complete fusion of the spine with more or less pronounced ankylosis of the hips and shoulders, but with relatively slight involvement of the other articulations of the extremities.

It is characterized by an ascending type of ankylosis in which the cervical spine is last and least affected. There is apt to be a greater degree of ankylosis of the hips than of the shoulders, while the sacro-iliac articulations are ankylosed quite early in the course of the disease. There is an excessive forward inclination of the trunk due to flexion-ankylosis of the hips, but the spine itself is more or less straight from the sacrum to the mid-dorsal area, above that point there is a definite forward inclination of the spine, producing kyphosis. The chest and pelvis show a definite flattening in the anteroposterior position, there is respiratory immobility of the thorax, and respiration is almost entirely abdominal.

In order to counteract the forward inclination of the body, these unfortunates stand with the knees flexed and thus maintain their equilibrium, their posture assuming, therefore, the shape of a Z. They are more comfortable in bed when lying either on the side or partly upright, with a support under the upper back and the head.

<sup>1</sup> Presented before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1, 1932.



The age of onset is usually in the third and fourth decades, but some cases are seen earlier and some after fifty years of age. The symptoms usually begin as pain in the spine and other joints, with early restriction of motion and final rigidity of the spine, which is bony in character and immobile even under anesthesia. Other symptoms are slight and transitory.

The process consists mostly in calcification of the spinal ligaments, with very little change in the intervertebral discs, which may tend to persist because of the fixation of the vertebræ by the bony wall around them. Most of the spinal ligaments participate in this bony enclosure. Ankylosis of the articular facets, and of the ribs with the vertebræ, is accomplished both by ligamentous calcification and by osseous proliferation. The sacrum is united to the ilia by osseous proliferation so that they become fused as one bone. The vertebræ themselves are not markedly changed. The ankylosis of the hips and shoulders is not due to ligamentous calcification as in the spine, for in these joints there is absorption of the articular cartilage, followed in turn by fibrous and bony union. Marie (2) says that we are dealing more with ossification of periarticular fibrous tissue than a veritable arthropathy.

On the roentgenogram, destruction of the sacro-ilia articulations is one of the first changes noted. Ankylosis is accompanied by irregular calcification in the ligaments of the lumbar spine without corresponding changes in the vertebræ or in the intervertebral discs. As the lesion progresses there is an increase in the amount of calcification in the bony wall around the vertebræ, until they are firmly united. It also gradually extends up the spine until the entire spine is involved. The cervical spine shows the least change, but frequently there is evidence of ankylosis. When lateral views of the spine are made, the intervertebral discs will show little change in thickness. The hips and shoulders do not show much change until the spine is well advanced in the disease process.

The following is an abstract of the essential features taken from Marie's original description of his first case (2). The patient was a farmer, 31 years of age. There was a history of a mild arthritis beginning at the age of 12, with several recrudescences of the disease. The right hip became ankylosed in 1884, which was twelve years before the date of this report. In 1886, the hips and spine became ankylosed, while the cervical spine was the last portion attacked. In 1889 the patient first complained of difficulty in swallowing, and there was gradual progression of the condition until the time of this communication. On Feb. 24, 1896, he presented himself to the author (Pierre Marie) with flexion of both knees. There was also flexion of the pelvis so that the man's trunk and legs presented a Z-shape. The trunk was inclined forward so that it was almost horizontal, the face looking downward at a point three meters from the feet. In order to maintain equilibrium in a standing position, he rested his hands on the anterior portions of the thighs. He had great difficulty in walking with or without crutches, and also difficulty in removing his trousers and shoes as he could not touch his feet with his hands. The hip joints at this time were rigidly ankylosed. In bed, he preferred to rest on the posterior lateral aspect of the trunk, lying on either side with the covers tucked under the parts which did not touch the bed. The thighs were flexed and the feet crossed one over the other. The movements of the upper extremities were restricted only in the shoulders. The excursion of the head in flexion and extension was very limited—it did not exceed 35 degrees—and there were only slight lateral movements. There was marked flattening of the thorax and the ribs were almost immobile during respiration, which was almost entirely abdominal. If the patient wished to look forward, he raised his head then flexed his knees, assuming a figure Z. The temporo-mandibular joints were normal; the spine was rigid and presented a sag

geration of the normal curve in the upper dorsal region, there was effacement of the normal curve in the lumbar area, and scoliosis was observed. The muscles were well developed.

This is a rather typical description of various cases that have been reported.

#### SPONDYLITIS MUSCULARIS—VON BECHTEREW TYPE

This condition was first described by Von Bechterew (3 and 4), who called it "stiffness, with humping of the back." There is a bow-like kyphosis of the cervical and upper dorsal spine, with a compensatory lordosis in the lumbar spine. The spine is sensitive to percussion and is markedly limited in motion. The chest is flat and immobile. The peripheral joints are not affected. It is a slowly progressive disease of unknown etiology, but it appears to bear some relation to trauma and heredity.

Knaggs (1) believes that the most important factor in producing the bow-like kyphosis is the feeble tone of the muscles. He believes that the atrophy of the intervertebral discs is also secondary to the muscular failure and is caused by the increase of pressure at certain points consequent upon the forward bending of the spine.

Von Bechterew studied the nerve root lesions associated with this condition and reports an autopsy on one case. There was evidence of degeneration of the nerve roots in the lower cervical and upper dorsal areas, but there were no changes in the upper cervical area and practically none in the lumbar area. In the areas affected, the posterior roots were almost entirely degenerated throughout, with less marked degeneration of the anterior roots. In the cord, the columns of Goll and Burdach were affected, the area of the latter corresponding to the entry of the posterior roots, and he believed that the degeneration could be explained on the basis of the chronic inflammatory changes in the meninges around the area. There was no

involvement of the spinal joints as in arthritis deformans, and no evidence of compression of the nerves due to narrowing of the spinal foramina.

This disease may begin in early life and later become stationary or may develop later in life. It is of the descending type, beginning in the lower cervical and upper dorsal areas, the other joints of the body seldom being affected. The spine becomes entirely rigid, due to fusion of the bodies of the vertebræ anteriorly, the intervertebral discs become narrowed or entirely disappear and when this happens, the vertebral bodies approximate and fuse anteriorly by a layer of bone. There is, however, no calcification of the ligaments as is seen in the Marie-Strumpell type of arthritis. There is conspicuous deformity, due to the rounded kyphosis in the upper dorsal and lower cervical areas causing the upper trunk and head to be projected forward to a noticeable degree.

The roentgenogram shows a rounded kyphosis of the upper dorsal spine, with narrowing of the discs and various changes in the vertebræ, ranging from slight bone production to complete bony fusion anteriorly. There is also a noticeable lack of extensive changes in the lower spine.

#### SPONDYLITIS SENILIS

Knaggs (1) and Steindler (5) believe the changes noted in the spine in old age may be regarded as a variation of spondylitis muscularis. In senile kyphosis we find narrowing of the discs, with fusion of the vertebræ which may also show narrowing. The normal curves of the spine are absent and there is apt to be a generalized arcuate kyphosis, with forward inclination of the head and upper trunk. In this condition the narrowing and disappearance of the discs are not limited to the upper dorsal area, but may extend throughout the spine. Knaggs (1) states that weakness and atrophy of the muscles progress simultaneously with shrinkage and disappearance of the intervertebral substances. He believes that

the weakened muscular power tends to aggravate the deformity

#### SPONDYLITIS OSTEOARTHRITICA—HYPER-TROPHIC ARTHRITIS

Hypertrophic arthritis of the spine is more apt to develop after fifty years of age and is most frequent in males. It is found many times in individuals who have been engaged in occupations requiring arduous labor and some authors feel that this has a definite etiologic bearing.

It is usually a generalized condition and is frequently associated with involvement of peripheral joints. The changes in the spine are similar to those in other joints in that there are marginal osteophytes with eburnation, and narrowing of the joint spaces in late cases. The eburnation is often not as marked, however, as it is in the peripheral joints, which appears to be due to the limited motion of the spinal joints as compared to other joints. Pain and restriction of motion are the common symptoms in early cases, with a dorso-lumbar convexity of the back in the late cases after absorption of the discs.

Baetjer and Waters (6) state that the first x-ray change to be noted will be a flattening of the edge of the vertebra where the lateral ligaments are attached. Exostoses form later at these points and slowly extend toward the adjacent vertebrae. These may develop until they form a bony bridge between the vertebrae. However, bony ankylosis of the vertebrae in hypertrophic arthritis is not the rule. In many advanced cases large hook-like spurs will be seen that appear to impinge but do not unite. Knaggs (1) says that a study of proven cases among museum specimens showed that fusion of the articular surfaces of the bodies and of the articular processes was unusual, that ankylosis of the ribs to the vertebrae had not occurred, and that the laminae and spinous processes were not united by bone. He believes that in instances in which fusion

did occur, "it was in circumstances where pressure and probably complete immobility were possibly determining factors."

#### RELATION OF PARATHYROIDIS TO ANKYLOSING SPONDYLITIS

Oppel (7) believes that spondylitis rhizomelique and spondylitis muscularis are stages of the same disease and that the difference is quantitative rather than qualitative. He prefers the name "ankylosing polyarthritis" to cover both conditions.

In studying a group of these cases, Oppel found a definite hypercalcemia and a decrease in the electro-excitation of the muscles. Since the hormone of the parathyroid bodies had been shown by Collip to increase the level of the blood calcium, Oppel concluded that hyperparathyroidism and ankylosing spondylitis were related. He proposed the theory that the arthritic syndrome developed after certain infections, in persons possessing a predisposition or constitutional tendency to hyperparathyroidism.

He quotes Samarin's study in 49 cases to the effect that, following parathyroidectomy, there was improvement in 33 cases and no improvement in the other 16. Oppel says that obviously the permanent changes cannot be cured but that the disappearance of hypercalcemia stops the process of progressive ankylosis and that this is the most important result of the removal of the parathyroid glands. He believes also that the reduction of the hypercalcemia in some way influences beneficially the function of the voluntary muscles, giving them greater freedom of movement.

LeRiche and Jung (8) also believe that in cases of polyarthritis associated with hypercalcemia, the removal of the parathyroids has much to offer and should be done early. Ballin and Morse (9) likewise include multiple ankylosing arthritis in the chapter on parathyroidism.

## DISCUSSION

It would be logical to attempt to classify the chronic arthritides of the spine under the broad headings—atrophic and hypertrophic—as are used in generalized arthritis. It is difficult to obtain an agreement on this, as the findings in the spine vary considerably from those in the peripheral joints. It is suggested by some authors that this may be due to the relative immobility of the spinal joints as compared to the peripheral ones. There are, in all probability, other factors such as abnormal pressure on the vertebral bodies due to lack of muscle tone or arduous labor, which would seem to play some part.

Spondylitis rhizomelique is usually classified under the head of atrophic arthritis. The changes in the spine itself vary from the peripheral type in that there is usually no narrowing of the joint spaces and no bone destruction and no bone proliferation, but rather a calcification of the periarticular structures. The etiology is usually ascribed to toxins from infectious processes as in atrophic arthritis. Hypertrophic arthritis is, of course, similar to hypertrophic arthritis elsewhere, with narrowing of the joint spaces and with varying degrees of marginal osteophytes, without ankylosis as a rule.

Great care must be taken in the evaluation of the changes shown by the roentgen film, owing to the osteophytic changes that may be present from static and mechanical stresses, and from senility. These help to explain the relatively extensive hypertrophic changes which are frequently found in the spine without a corresponding degree of symptoms. Spondylitis muscularis, or the Von Bechterew type, and the so-called senile kyphosis are placed in the hypertrophic group by Stenlder (5), who believes that faulty posture, occupational strain, etc., may predispose to this condition. Knaggs, as noted above, is of the opinion that feeble tone of the muscles, with a consequent increase of pressure on the vertebræ by forward

bending of the spine, is the most important etiologic factor. Heredity is also said to be a factor and various members of a family may be affected.

Spondylitis rhizomelique usually begins in the third and fourth decades or even earlier. Spondylitis muscularis may also begin in early life, and later become stationary, or may develop later in life. Hypertrophic arthritis usually begins after fifty, but may show some changes earlier.

The ankylosis of the spine produced by these arthritides is another point of classification by certain authors. They place spondylitis rhizomelique and spondylitis muscularis in one classification and designate them by the term "chronic ankylosing polyarthritis," or "spondylitis ankylopoietica." Spondylitis rhizomelique is an ascending ankylosis, beginning in the sacro-iliac joints and progressing up the spine until the entire spine is held rigidly by calcification of the ligaments surrounding it. Spondylitis muscularis is of the descending type, beginning in the upper dorsal and lower cervical spine and often not involving the lower lumbar area. In this, the vertebræ are approximated by absorption of the discs and the vertebræ are united anteriorly by a bridge of bone. Hypertrophic arthritis, on the other hand, produces huge osteophytic spurs around the vertebral margins, but usually does not produce ankylosis. Oppel (7) not only designates spondylitis rhizomelique and spondylitis muscularis as stages of the same disease, but believes the etiology to be hypercalcemia induced by hyperparathyroidism. He recommends removal of the parathyroids in the treatment of this condition. He does not claim a disappearance of the existing arthritis but states that as the hypercalcemia is eliminated, the progressive ankylosis stops. He also believes that there is a greater freedom of movement of the voluntary muscles. These observations have been confirmed by several other authors. We believe that many more observations over a longer period of time are necessary before this theory can be fully accepted.

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# CANCER OF THE PROSTATE

THE RESULTS OF RADIUM AND ROENTGEN-RAY TREATMENT<sup>1</sup>

By BERNARD P. WIDMANN, M.D., *Philadelphia*

From the Radiological Department of the Philadelphia General Hospital

THE purpose of this paper is to evaluate the results of roentgen-ray and radium treatment for 152 cases of cancer of the prostate in the Radiological Department of the Philadelphia General Hospital. Since nearly every case required admission to the hospital when first seen, the study obviously resolves itself into an analysis of the palliative benefits of radiation for clinically advanced cases. The question is often raised: How much value is high voltage radiation for the late and advanced cases? Is it really worth while?

With this object in view it seemed necessary (a) to associate the relevant clinical data of age, duration of symptoms, diagnosis, extent of involvement, bone and gland metastasis as well as pathologic characters, and (b) to outline and discuss the technical procedures of radiation employed.

For the study of the irradiation group, 82 cases were selected because they were known to have received an adequate dose of high voltage roentgen rays as compared with a clinically similar group of 70 cases receiving no irradiation. Every patient in this series died. The terminal stages of the disease in each instance were typical of cancer.

The clinical factors were so variable that it was obviously difficult to evaluate end-results on the basis of statistics. Moreover, the beneficial effects are not always in conformity with statistical estimations, neither is the palpable extent of involvement a true record of the actual extent of the disease. The time incidence of the first symptom on hospital records does not always indicate the onset of the disease by any means.

In many instances roentgen-ray studies are negative for bone metastasis, yet it is possible for metastasis to exist and to be of such slight involvement that it is not readily subject to x-ray demonstration. There were several instances in this series in which cases presented lumbar and sacro-iliac pains of sufficient intensity to justify the inference of metastasis, yet this evidence was not obtained to a definite and indisputable degree for as long as from two to four months in five cases in this group.

The advanced stages of the material in these 152 cases is indicated by the fact that 82 per cent were admitted to the hospital when first seen, only 18 per cent being at first treated as ambulatory cases. On the other hand, the cases with high or medium degrees of malignancy are probably representative of the average case from the standpoint of duration of symptoms when medical advice is first obtained, because the average duration of symptoms at the first consultation was from six to twelve months. The only cases in this series that are probably not representative of what might be regarded as clinically "early," are the group of so-called low grade malignancies.

In this series there were 101 out of 152 patients who recognized symptoms within 12 months, grouped as follows: 57 within 6 months, 42 within 12 months, 27 with definite symptoms persisting over a period of two years, 6 for 3 years, 7 for 4 years, 8 for 5 years, and 5 had symptoms longer than 5 years. These latter two groups were obviously low grade malignancies and the life cycle from admission to death was brief because of a rapidly failing health and strength on admission, compatible with the terminal stages. These observations on the duration of

<sup>1</sup> Read at the Eighteenth Annual Meeting of the Radiological Society of North America, at Atlantic City, Nov. 28-Dec. 1, 1932.

When the characteristics of spondylitis rhizomelique and spondylitis muscularis are compared, it seems rather odd that they should be considered as stages of the same process. The pathology of the two conditions is quite different, the signs and symptoms and development of the two diseases are also radically different, the etiology, as given by most authors, is also distinct—the main points of similarity are ankylosis of the spine, with kyphosis in the upper portion.

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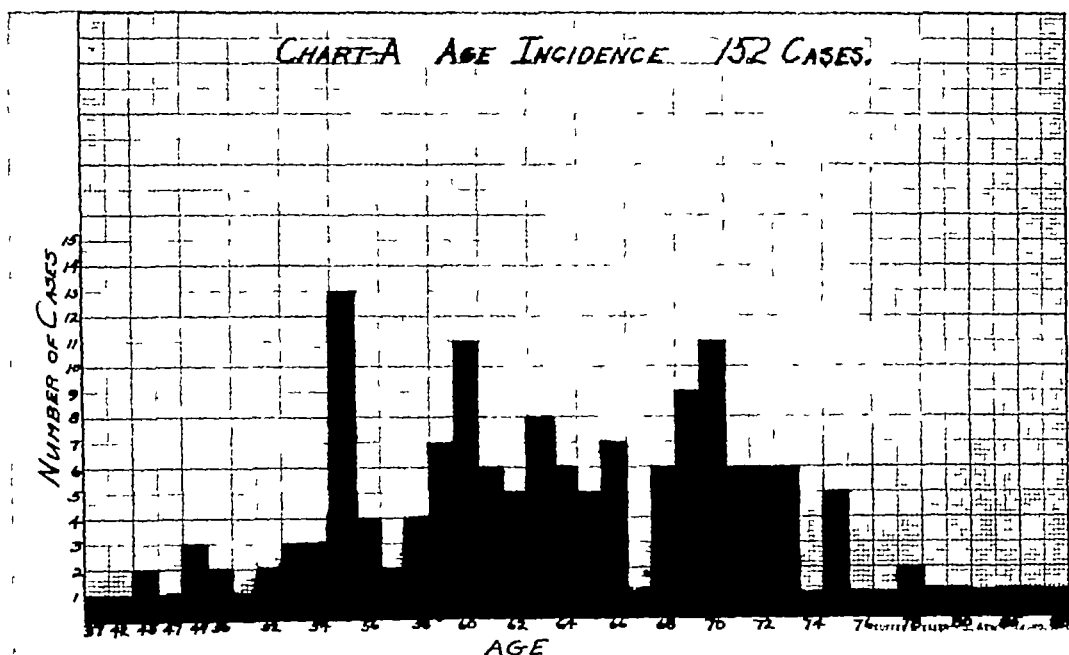


Chart A Age incidence, based on 152 cases

symptoms from the first recognition by the patient until admission to the hospital are important because they show that 128 (84 per cent) of the cases presented symptoms over a period of less than two years. This evidence points to a preponderance of material coming within the range of the higher grade types of malignancy. The relatively short life—from the time of admission which was the time of beginning irradiation, and discussed in more detail later—substantiates this inference of clinically high grade malignant cases.

The age incidence is not significant. As shown by Chart A, the preponderance of cases occurred between 55 and 75 years. The correlation of age with the extent of residual urine, duration of symptoms, extent of involvement, and the cellular differentiation is an especially important prognostic criterion, and the facts brought out by it will be dealt with in more detail later.

Frequency, difficulty in urination, painful urination, and nocturia were the outstanding symptoms. It is significant to

note the frequency of the symptom of weakness and especially loss of weight (Table I). "Backache" was so prominent and varied in its distribution that it should always be regarded with suspicion after middle life. Pain constituted a major complaint in nearly 70 per cent of these cases.

The symptom of obstruction was frequently described as "difficulty on urination," and records are not entirely satisfactory on this score.

Bone metastasis occurred in 38.5 per cent of 152 cases. The incidence of bone metastasis in other reports has been about 30 per cent—Bumpus (1), Ferguson (2), Smith and Pierson (3). Chaulk and Boonitt, (4) state it to be 18 per cent in their cases.

The most frequent site of bone metastasis was in the pelvis (Table II), a region which was affected in 51 out of 60 cases. Lumbar spine involvement was next in frequency, the chest was involved in nine cases, and the skull in six. In none of these patients was metastasis found below the

elbow or knee joints    Pathologic fractures  
were noted in only four cases

TABLE I —INCIDENCE OF FIRST SYMPTOMS  
AS NOTED BY THE PATIENT

Frequency	80	Cases
Difficulty in urination	76	"
Painful urination	71	"
Nocturia	69	"
Weakness	61	"
Pain in back, hips, and knees	59	"
Obstruction	47	"
Loss of weight	43	"
Hematuria	42	"
Burning	37	"
Lumbar pain	33	"
Sacro-iliac pain	30	"
Polyuria	28	"
Incontinence	20	"

TABLE II —INCIDENCE OF BONE METASTASIS

Pelvis	51	Cases
Lumbar spine	38	"
Femora	18	"
Dorsal spine	16	"
Ribs	14	"
Humeri	10	"
Chest	9	"
Skull	6	"

TABLE III —RECTAL EXAMINATION OF THE  
PROSTATE

Enlarged	99	Cases
Hard	96	"
Nodular	43	"
Painful	23	"
Irregular	21	"
Clinically normal	21	"

The Wassermann test was positive in only 12 cases, an incidence within the average range of 10 per cent positives for males. Enlarged inguinal nodes were detected in four cases, an interesting observation which conforms with the relative infrequency of inguinal node metastasis in cancers of the female pelvis (excepting vulva), and is supported by the studies of Chaulk and Boon-itt (4) and Dossott (5). Edema of the extremities was present on admission in 14 cases—in nine of them the edema was marked, and existed in three of those cases referred from other hospitals following partial prostatectomy.

There had been surgical intervention in 11 cases before admission, as follows: recurrence following prostatectomy, five cases; cystostomy, four cases; and punch operation, two cases.

In every instance the clinical diagnosis was obvious on the basis of rectal findings of enlarged, hard, nodular, and infiltrating characters of the prostate gland. The size in each instance was in excess of 5 cm diameter. In 21 cases the prostate was normal as far as could be determined by a clinical examination; the diagnosis was made accidentally following roentgenographic studies for "backache" in 18 cases. Operation for obstructive symptoms in three clinically normal cases revealed carcinoma.

It is well known that minute growths of the prostate escape detection (Chaulk and Boon-itt, 4, Hirsch and Schmidt, 6). A negative report on tissue cannot eliminate carcinoma unless the entire gland has been carefully sectioned. Three cases in this series had prostatectomy elsewhere for a clinically hypertrophied prostate; in two cases carcinoma was not recognized, in one case a small pea-sized nodule was found on careful sectioning and reported malignant. All three of these cases had extensive local recurrence on admission within one year after the operation.

Ferguson (2) reviewed the literature of 1,426 cases in which the prostate was removed with the clinical diagnosis of benign enlargement, and in which 183 early or borderline cancers were found. Not one of these cases showed the posterior lobe involved but, rather, the lateral or median lobes.

Cunningham (7) found carcinoma of the prostate in 20 per cent of the obstructive prostatic cases. Of 700 cases with obstructive symptoms, Barney and Gilbert (8) found that 23.9 per cent of their prostatic cases were due to malignancy. Davis (9) found 250 cases of cancer of the prostate occurring in 2,000 instances of prostatic obstruction observed at Johns Hopkins Hospital. This experience led him to conclude that cancer of the prostate should be suspected in the presence of extensive induration, fine nodules, or induration and obliteration of the median notch of the bladder base.

Benign hypertrophy does not exclude

the possibility of carcinoma. Microscopic studies were made in 40 cases—11 suprapubic operations, and 29 autopsies. An attempt was made to evaluate the end-results of irradiation or no treatment, according to the clinical course of the disease, age of patient, duration of symptoms, extent of involvement, residual urine, and cellular differentiation of the growth according to the observations of Ferguson (2). He describes three clinical types of carcinoma characterized by such a clinical syndrome and certain pathologic features which he found to be indicative criteria for establishing a prognosis. The cases were accordingly classified as high, intermediate, or low malignancies, with an average life of 6 months, 18 months, and from 30 months to many years, respectively. The age incidence was 55, 60, and over 65 years for the high, medium, and low malignancies, respectively.

Dr Custer, of the Pathological Department of the Philadelphia General Hospital, is at present making an exhaustive analysis of this group of cases which he will report in detail at a later date. His preliminary findings seem to support the clinical index factors of malignancy observed by Ferguson.

There is ample evidence to indicate that the clinical diagnosis for early cases is difficult. When this diagnosis is suspicious from the standpoint of symptoms, and a rectal examination demonstrates enlarged, hard, and nodular infiltrations, then the case is probably advanced and well out of range of operability. Obstructive symptoms may occur in carcinomas of the prostate, but may also be the result of simple hypertrophy. Many early lesions of the prostate have been discovered accidentally following prostatectomies for clinically benign hypertrophies.

High voltage radiation has been of tremendous benefit not only from the standpoint of relief of pain, but for relieving obstructive symptoms. Smith and Pierson (3) do not believe that radiation is beneficial in relieving obstruction. Barringer is of the opinion that at least from

5 to 10 per cent of prostatic tumors are highly cellular and undifferentiated types of cancer, and, therefore, most malignant and most sensitive to radiation.

It is difficult to estimate the effects of roentgen rays on the size of the growth. In the majority of these cases the growth ranges from 5 to 7 cm. in diameter and in a few instances even larger. There is generally infiltration about the seminal vesicles, and almost always symptoms associated with a cystitis and sometimes a pyelonephritis. The question of supportive operative procedures such as punch and cystostomy or retention catheters must always be considered. It is difficult to evaluate these methods because each case is an individual problem and must be analyzed from the standpoint of operability.

Barringer (10) believes that it is possible to control from 10 to 15 per cent of cancers of the prostate for three years or more by irradiation methods. In many cases in which the disease is confined to the posterior region of the prostate, between the fascial planes, and without involvement of the bladder neck, the use of radon needles implanted through the perineum is advised. In cases in which the tumor involves the bladder neck, cystotomy and implantation of gold radon seeds into the prostatic tumor are to be preferred.

Davis (9) believes that a limited number of cancers of the prostate are suitable for radical prostatectomy. Many more cases benefit by the implantation of gold radon seeds in the tumor after either perineal or suprapubic exposure.

Geraghty (11) believes that surgery alone is hopeless in 95 per cent of the cases of carcinoma of the prostate. The combination of surgery and radium seems to offer the best results according to Bumpus (1), Chute (12), Barney and Gilbert (8). Chaulk and Boon-itt (4) advocate the punch operation to relieve obstructive symptoms, and combine this procedure with radium or roentgen rays or both to effect growth restraint. Smith and Pierson (3) recommend roentgen-ray treat-

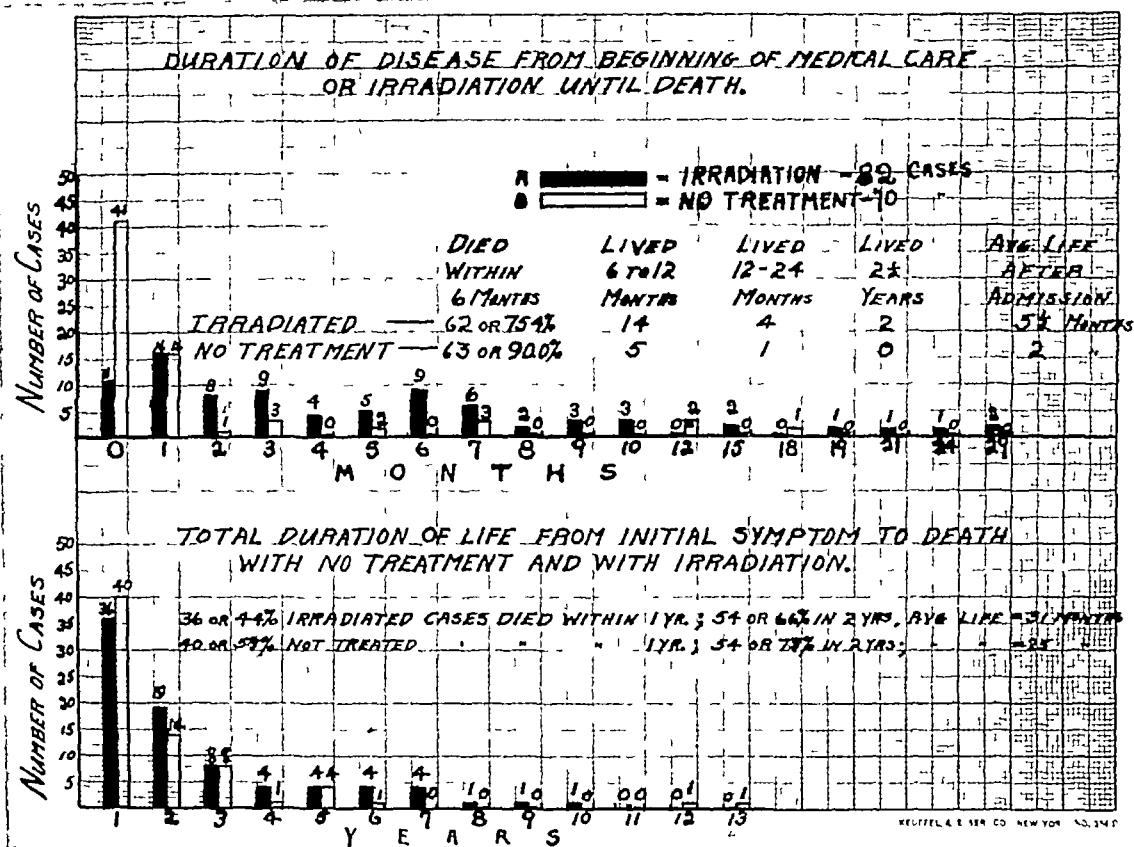


Chart B

ment for cases not suitable for surgery Attwater (13) discusses at length the relative merits of surgery and radiation and favors radiation

Roffo and Astraldi (14), after an extensive review of the literature on the effects of radium, roentgen rays, and surgery for cancer of the prostate and on the basis of their own experience also, conclude that the results have been most unsatisfactory, and that the only treatment is palliative cystotomy Astraldi (15), reporting the service of Professor Lequen of Paris, prefers not to interfere surgically, believing that the patient will have a longer life if left undisturbed He has discarded roentgen rays and radium

Pain, frequently relieved when roentgenographic evidence of metastasis has been proven, may be due to perivascular or perineural metastatic infiltrations, the pressure of enlarged infiltrating prostatic neo-

plasms or enlarged nodes, and cystitis or pyelonephritis In radiosensitive lesions the relief of pain is sometimes phenomenal In many instances, growth restraint is obtained by way of increased fibrous tissue formation, especially if the treatment can be carried out over an intermittent period of from six to twelve months

The life cycle evaluation is not of much value without an analysis of each case record The disease probably exists in many cases for a long time before any definite symptoms are recognized by the patient Radiation treatment is of no special value for metastatic bone disease except from the standpoint of relief of pain It does not retard progressive bone changes

The factor which indicates beneficial effects of radiation is chiefly relief of pain Diminutions in the extent of the primary growth and relief of obstructive symptoms

the possibility of carcinoma. Microscopic studies were made in 40 cases—11 suprapubic operations, and 29 autopsies. An attempt was made to evaluate the end-results of irradiation or no treatment, according to the clinical course of the disease, age of patient, duration of symptoms, extent of involvement, residual urine, and cellular differentiation of the growth according to the observations of Ferguson (2). He describes three clinical types of carcinoma characterized by such a clinical syndrome and certain pathologic features which he found to be indicative criteria for establishing a prognosis. The cases were accordingly classified as high, intermediate, or low malignancies, with an average life of 6 months, 18 months, and from 30 months to many years, respectively. The age incidence was 55, 60, and over 65 years for the high, medium, and low malignancies, respectively.

Dr. Custer, of the Pathological Department of the Philadelphia General Hospital, is at present making an exhaustive analysis of this group of cases which he will report in detail at a later date. His preliminary findings seem to support the clinical index factors of malignancy observed by Ferguson.

There is ample evidence to indicate that the clinical diagnosis for early cases is difficult. When this diagnosis is suspicious from the standpoint of symptoms, and a rectal examination demonstrates enlarged, hard, and nodular infiltrations, then the case is probably advanced and well out of range of operability. Obstructive symptoms may occur in carcinomas of the prostate, but may also be the result of simple hypertrophy. Many early lesions of the prostate have been discovered accidentally following prostatectomies for clinically benign hypertrophies.

High voltage radiation has been of tremendous benefit not only from the standpoint of relief of pain, but for relieving obstructive symptoms. Smith and Pierson (3) do not believe that radiation is beneficial in relieving obstruction. Barringer is of the opinion that at least from

5 to 10 per cent of prostatic tumors are highly cellular and undifferentiated types of cancer, and, therefore, most malignant and most sensitive to radiation.

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determinate period of time before the recognition of the first symptom, (2) the degree of local involvement and the extent and duration of metastasis cannot always be estimated accurately, (3) averages of a large group of a 1,000 or more cases are necessary to set up substantial criteria for such estimations, (4) unless microscopic studies with special reference to the cellular differentiation are carried out in each case, the variable responses to irradiation cannot be properly evaluated.

This series of 152 cases represents an extremely advanced type of case. Bone metastasis was found in 40 per cent, hospital care was necessary in 82 per cent when first seen.

A correlation of the clinical data with cellular characters in 40 of the cases supports the findings of Ferguson (2) of a decided relationship to the longevity cycle and the prognosis—the more highly cellular, the more highly malignant, and, conversely, the more highly radiosensitive.

Enlarged, hard, infiltrating, and nodular prostates are almost always certain evidence of malignancy. Local involvement of this extent generally indicates inoperability. The success of surgery in many reported cases of clinical cures seems to have resulted from accidental findings of malignancy following prostatectomies for simple hypertrophies.

There is not sufficient material in this report to evaluate gold seed implantations. Supplementary heavily filtered radium tampons have been beneficial in the highly cellular growths, but the total dose should never be in excess of one erythema dose because of the distress resulting from rectal irritation. High voltage roentgen rays in 82 cases of this series have been of tremendous benefit in relieving pain and diminishing obstructive symptoms. These results have been so striking in a large number of cases that the recommendation of high voltage irradiation procedures for advanced cancer of the prostate is justified in every case in which the physical condition of the patient is sufficiently good to tolerate intensive treatment. There is

some evidence in this series of cases to indicate an increased duration of life from irradiation. In selected early cases this result may be expected to be great.

#### SUMMARY

Beneficial effects for the most part must be determined on a basis of immediate clinical results.

The early diagnosis is difficult. The aspiration method holds out great possibilities in this respect.

Cancer of the prostate is essentially a radiologic problem. In selected early cases, interstitial radiation with gold seeds or platinum needles should offer great possibilities of improving the end-result.

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have also been noted in many instances. The general health and duration of life are not especially valuable criteria for estimating beneficial effects of radiation, because these conditions may be affected by a carcinoma which existed long before symptoms developed, or complications of a cystitis or pyelonephritis, as well as unrecognizable metastasis.

The duration of life after admission to the hospital was five and a half months for 82 irradiated cases, as compared with two months for 70 cases receiving no treatment (Chart B). Of the irradiated cases, 75 per cent died within six months after beginning treatment, as compared with 90 per cent receiving no treatment. Four cases lived from 12 to 24 months and two cases lived 29 months with irradiation. Only one case lived beyond a year (18 months) without treatment after admission. The average total life for the irradiated group of 82 cases was 31 months, as compared with the average total life of 25 months in the group of 70 cases receiving no treatment. There was 34 per cent of the irradiated cases alive at the end of two years, as compared with 25 per cent of those receiving no treatment.

Chaulk and Boon-itt (4) found an average life of from 25 to 38 months with combinations of radium, roentgen rays, and punch operation, as compared with radium or roentgen rays alone combined with punch operation.

Bumpus (1) found that 31 per cent of the cases treated surgically survived two years, as compared with a group of radium-treated cases which showed only 17 per cent surviving for two years. Of the cases receiving no treatment, 92 per cent died in two years. The average post-operative life reported by Bumpus was 27 months, as compared to 28 months for the radium-treated cases.

The technic of high voltage roentgen-ray treatment was as follows: 200 K V, 30 ma, 0.5 mm Cu plus 2 mm Al, 50 cm distance, field  $15 \times 20$  sq cm, cross-fire, 4 fields over pelvis, so-called mechanical rectification. The dose with these

factors is 800 r units. The treatment was carried out along the lines of saturation (Pfahler), and the four fields as recommended by Weatherwax and the writer. At the end of about two weeks a total dose of approximately 200 per cent ESD was attained in the tumor-bearing area, according to depth dose chart estimations. At the end of six weeks, if the physical condition of the patient permitted, another such series of treatments was given. Of 82 cases treated, 34 received one series of treatments, 29, two series of treatments, 15, three series of treatments, and 4 were given four series of treatments. In 19 cases, the first series of treatments was supplemented with heavily filtered radium packs to the anterior and posterior pelvis. This additional radium treatment amounted to approximately 125 per cent additional radiation to the skin. In 17 cases, rectal tampons were used with an estimated dose ranging from 0.5 to 3 ESD. The filtration for the rectal tampons was 0.5 mm silver and 3 mm lead, which is equivalent to the density of 2 mm of platinum. There was no evidence to indicate that the rectal tampon treatment offered any special benefit except in a few instances in which the growth was apparently highly cellular in character and the relief of obstructive symptoms was marked.

In eight instances gold seed implantations were used, but the marked clinical extent of local involvement was such that the results were not satisfactory. This experience was sufficient to set up a new working basis for interstitial radiation, which will be confined in the future to cases with clinical involvement well within the confines of surgical operability.

#### CONCLUSIONS

It is difficult to evaluate irradiation for advanced cancer of the prostate on the basis of the total longevity cycle or even the total duration of life from the beginning of treatment for the following reasons: (1) disease may have existed for an in

the majority of cases to obtain satisfactory outlines of the filled esophagus. A barium mixture which is definitely thicker than that used in the ordinary gastric series is recommended and, it goes without repeating, careful rehearsing and instruction of the patient are essential to good results. We believe that if these methods are followed carefully, any roentgenologist can produce good radiographs of the normal filled esophagus without much practice and with no added expense.

It might be well to pause at this point to offer some conjectures as to the cause of the phenomena noted. At the present time, the best that one can do is offer conjectures, because it is universally accepted that up to the present time very little is really known concerning the innervation, structure, and function of the tissues forming the cardiac opening. Rake and others have made exhaustive microscopic studies of tissue removed at autopsy from the lower end of the esophagus of a few patients suffering from so-called "chronic cardiospasm," but such exhaustive studies have not, to our knowledge, been carried out in individuals having a normal esophagus and dying from other causes.

In one specific case of chronic cardiospasm, Rake made something over two hundred serial section studies embracing not only the region of the cardia, but also the adjoining segments above and below. In these sections, he states specifically, definite degenerative changes were seen in Auerbach's plexus in and near the cardia, but in the adjacent portions above and below, an almost normal appearance of the plexus was noted.

In the same article, Rake states, in reference to the work of Berkell, "He has shown that the ganglion cells of Auerbach's plexus are all cell stations on the vagus." Langley, Kronecker, and Meltzer substantiate Rake's views and conclude that "the production of achalasia (lack of normal relaxation) of the cardia must depend on a lesion of the vagus nerves somewhere in their course." Other observers have been unable to demonstrate these changes in

Auerbach's plexus in cases of so-called chronic cardiospasm. In fact, one of us (E. B. F.) has recently reported a case of extreme cardiospasm which came to autopsy, in which, according to Dr. Clarence L. Cohn, of Dr. Bloodgood's laboratory, no degenerative changes in Auerbach's plexus were demonstrable.

As to the matter of sympathetic nerve supply, Gaskell states that the esophagus receives no sympathetic nerve supply. Other observers have stated to the contrary—that the esophagus receives sympathetic fibers throughout its whole course. Rake says that "the truth lies between the two extremes. The extent of the sympathetic supply has never been accurately determined, but it seems probable that at least the whole of the sphincter receives a dual nerve supply." It is quite evident, therefore, that the matter of nerve supply of the so-called cardiac sphincter is still very much unsettled and is still a highly controversial subject.

As to the musculature surrounding the cardiac opening, there is almost an equal amount of controversy, to the extent that some observers have denied the very existence of a cardiac sphincter. Jackson has suggested that the crura of the diaphragm may be the sole structures furnishing the sphincteric effect at this point, whereas, on the other hand, Baillet, in 1807, described a true anatomical sphincter. In all fairness to both views, Rake concludes, from radiologic studies, that, regardless of whether or not a true anatomical sphincter exists, "the last inch, or more, of the esophagus has such a totally different function from that of the rest, that it deserves to be regarded as a functional sphincter."

As far as the function of the lower inch or more of the esophagus is concerned, it has been quite definitely observed both by auscultatory and fluoroscopic means, that a single swallow of fluid hesitates normally at the cardia at least six or eight seconds, before entering the stomach. We do not know the exact reason why this should be true. We are personally



# NEW METHOD FOR VISUALIZATION OF THE UNOBSTRUCTED ESOPHAGUS<sup>1</sup>

By HAROLD E. WRIGHT, M.D., and ELMER B. FREEMAN, M.D., *Baltimore, Maryland*

From the Gastro-intestinal Department, Johns Hopkins Hospital

It has always been quite simple, with the aid of a thick barium mixture, to obtain satisfactory radiographs of the obstructed, or partially obstructed, esophagus, but the normal or unobstructed esophagus has presented a more difficult problem. In view of these difficulties, various devices have been instituted such as having the patient swallow the barium mixture while in the horizontal position or the more elaborate procedure of introducing a fish skin filled with barium into the esophagus. All of these methods having been productive of more or less indifferent and uncertain results, it occurred to us that there might be some procedure by which at least a partial voluntary control of the so-called "cardiac sphincter" could be brought about. With these thoughts in mind we set about accomplishing this result, with what, we feel, is a gratifying degree of success.

From long experience in esophagoscopy examinations, one of us (E. B. F.) was forcibly impressed by the fact that, in almost every instance, while viewing the cardiac opening through the esophagoscope, it was seen to open and close rhythmically, synchronous with respiratory action. With this fact in mind, we set about making extensive fluoroscopic studies of the swallowing act, using a rather thick barium mixture. The subjects upon which these studies were made were persons who had never had the slightest suggestion of dysphagia or even a history of temporary cardiospasm.

Of course, it is axiomatic that respirations must be suspended in order to accomplish the deglutitory act, also, it must be understood that all of these studies were made with the patient in the erect

position. The results revealed some very interesting facts which may be briefly stated.

1. Barium swallowed at the end of a full forced inspiration passes at a leisurely rate through the cardia into the stomach.

2. Barium swallowed when respiration is suspended in the midst of a normal inspiration or expiration passes very rapidly through the esophagus and cardia in a thin stream, the organ itself being in a more or less collapsed condition.

3. Barium swallowed when respiration is momentarily suspended at the end of a forced expiration is held in the esophagus for several seconds and causes a rather remarkable dilatation of the organ, which, in some cases, is almost as marked as is seen in early cardiospasm.

Of course, if too much fluid is swallowed, even following forced expiration, the temporary sphincteric action is overcome by sheer weight and volume and the whole mass rushes precipitously into the stomach. We have usually found that two or three moderate swallows of fluid were sufficient to produce the desired result and yet not enough to overcome the sphincteric action.

*Procedure*—Having completed our fluoroscopic studies, we proceeded to attempt to obtain satisfactory radiographs of the normal esophagus. The subjects were placed standing in the right anterior position against the upright cassette and instructed to take two or three deep breaths. At the end of a forced expiration they were told to swallow two or three mouthfuls of a rather thick barium mixture and as soon as this had been accomplished, the exposures were made. This procedure was rehearsed two or three times in order that there might be no misunderstanding and to make sure of satisfactory results. By this method we were able in

<sup>1</sup> Presented before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28-Dec. 1, 1932.

# SOME NEW PRINCIPLES IN THE DESIGN OF X-RAY APPARATUS<sup>1</sup>

By A. BOUWERS, D.Sc., Eindhoven, Holland

Philips X-ray Research Laboratory

FIVE years ago the writer had the privilege of reading a paper in this city before the Radiological Society of North America on the subject of "Self-protecting Tubes and Their Influence on the Development of X-ray Technic"<sup>2</sup> Some of the principles already mentioned in that paper led to the design of fully protected, shock-proof x-ray tubes and apparatus, both for diagnosis and therapy. It is with great pleasure that to-day he finds opportunity to report on a few of the newer principles worked out by this laboratory. Some of these new features have been published in European periodicals only recently, the others, however, have not hitherto been published anywhere.

*A Reduction of exposure time for x-ray tubes with stationary anode by a new method of loading*—The maximum temperature of the anode surface is normally reached only at the end of the exposure time. The temperature rises, as is indicated in the drawn line of Figure 1-A. A larger load would be permissible at the beginning of the exposure, as the temperature of the anode is then far below its admissible limit. The increase of load may be such that the temperature limit is reached practically at once and then maintained during the whole exposure time. With such an increased load it is obvious that an exposure may be made in a shorter time than would be possible with a normal load.

Figure 1-B represents in the drawn line the exposure of constant load, the dotted line represents the initially increased and then decreased load, the total exposure being the same in both cases.

Calculation and experiment show that a reduction of exposure time of about 40

per cent is possible with this new method. Figure 2-A shows the results of the calculation of temperatures in and behind the

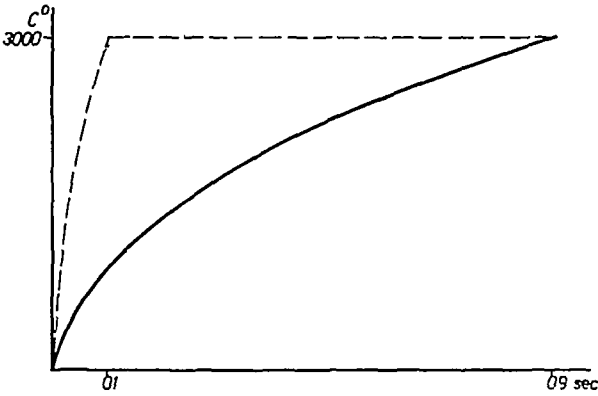


Fig 1-A Rise of temperature during a normal load (continuous curve) and during a falling load (dotted curve)

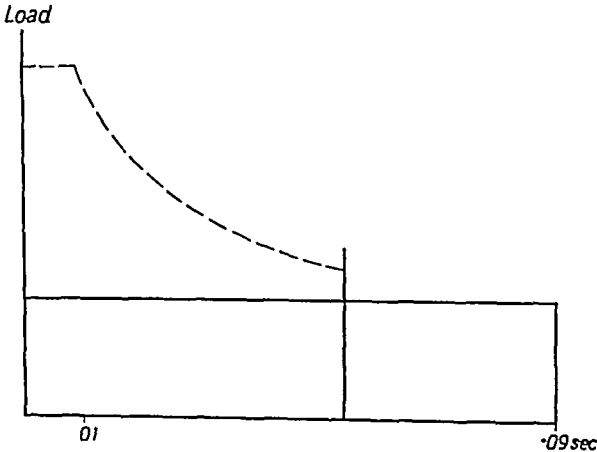


Fig 1-B Represents the two loads. The total power is approximately equal in each case.

anode surface for different exposure times for constant load.

Figure 2-B shows the temperature curves for decreasing load, the maximum temperature of 3,000° being maintained from the

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

<sup>2</sup> RADIOLOGY, September, 1929, XIII, 191.

convinced, however, that, aside from the nervous and muscular control of the cardiac opening, certain mechanical factors incident to normal respiratory movements have varying effects upon the deglutitory function, either through the effect of the movements of the diaphragm or through the production of definite intrathoracic pressure changes. The more so because, while experimenting with a balloon in the cardia of dogs, we have noted a remarkable dilatation of the cardia resulting from stimulation of the phrenic nerves and consequent strong contractions of the diaphragm. The pressure factor, of course, was entirely eliminated in this instance because the thorax had been opened in order to stimulate the phrenics artificially.

We are also convinced that certain anatomical features consequent to the bodily form of the subject and causing a variation of the course of the esophagus, particularly in the lower third, have a direct bearing upon the above-mentioned mechanical features. In the case of long-chested individuals with a narrow costal arch, we have seldom failed to get a satisfactory outline of the esophagus on the very first attempt. On the other hand, we have had considerable difficulty and not a few failures in individuals with a short chest and wide costal angle.

In this connection we have found that there are a certain small number of indi-

viduals who retain the barium in the esophagus much better at the end of a full inspiration than at the end of a forced expiration. It is inconceivable that these individuals should be possessed of a diametrically opposite innervation from that usually possessed by the average normal person, and, in consequence, we have been forced to attribute this result to some mechanical factor. In fact, this reaction is characteristic of all the cardiospasm cases which we have studied, *i.e.*, the esophagus retains the barium much better at the end of a full inspiration than it does after forced expiration. In fact, it is possible that these individuals may be classified as potential cardiospasm cases, or, if Rake be correct in his assertion, that the condition is not one of true spasm but, rather, a lack of normal relaxation of the cardia. It seems plausible that varying degrees of this normal relaxation may be found even in cases not suffering to any appreciable extent with symptomatic esophageal disease.

At any rate, we feel that we have been able through this procedure, to outline a great many cases of normal esophagus and, with continued effort, we hope to be able to throw more light, not only upon the normal function of deglutition, but also as time goes on, to contribute something of value to the knowledge of that very interesting condition known as "chronic cardiospasm."

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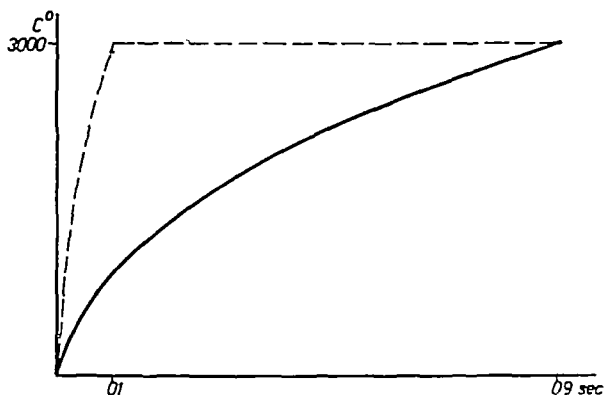


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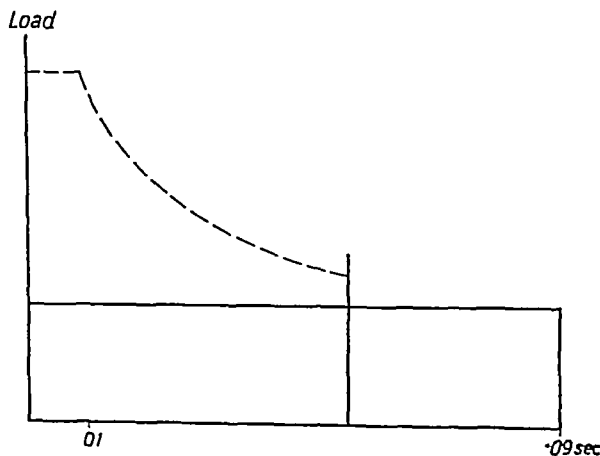


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beginning. A more complete description has been recently published.<sup>2</sup>

The decreased load with constant volt-

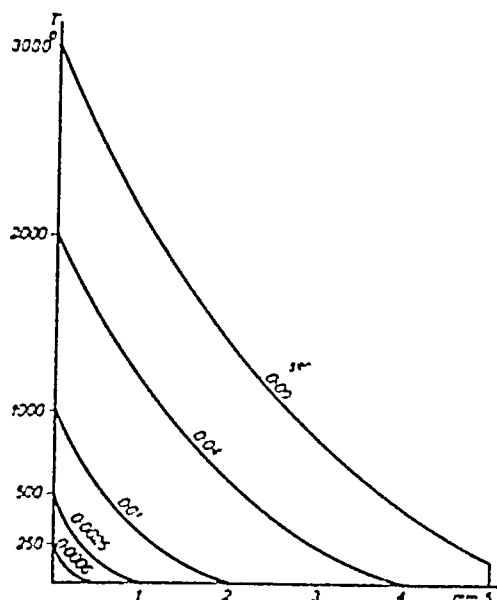


Fig. 2-A Distribution of temperature in the anode during normal load. Gradient at the surface constant

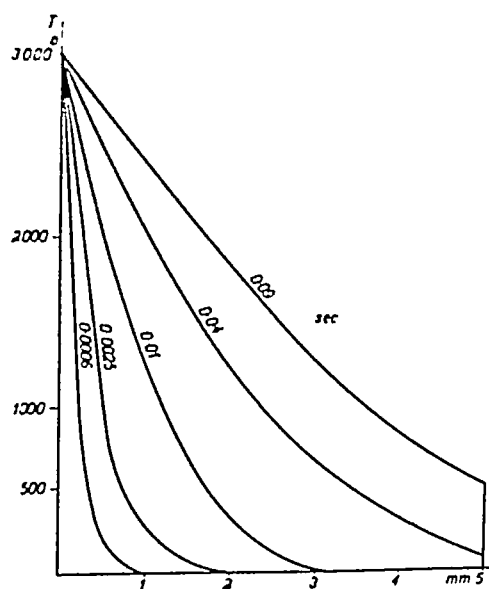


Fig. 2-B Distribution of temperature in the anode during a falling load after different exposure times. Gradient at the surface decreasing

age is obtained by automatically altering the filament resistance of the tube after a very short time. The electron emission of the filament decreases with the decrease of temperature of the filament.

*B Automatic load-control*—The method of decreasing load has proven to be very useful, quite apart from the effect of reduction of exposure time which has just been described. To explain this fully, we will make a comparison between radiological technique and lighting technique. An incandescent lamp, used with its proper voltage, will automatically burn at a temperature which guarantees at the same time a reasonable lifetime and a good luminous power. It is not necessary to adjust the filament current, which would, by the way, be very difficult, it would certainly result in a considerable reduction of the life of the lamp and in most cases in a useless reduction of light.

We may say that an incandescent lamp is automatically charged at its limit capacity and this charge at limit capacity is of no less importance with an x-ray tube than it is with an incandescent lamp. Therefore, in the Philips Standard Unit the current is automatically connected with the tension in such a way that the wattage is the same for every exposure. The result is maximum output of x-rays and at the same time a guarantee for a reasonable lifetime of the tube. For apparatus of very short exposure times, however, there is a marked difference between the permissible load during, say,  $1/30$  of a second and the permissible load during  $1/3$  of a second, so that a constant wattage for every exposure would not be practical.

Here the decreasing load just described supplies an easy solution. If the load is such that the anode temperature is kept at its permissible limit during the whole exposure time, the exposure may be stopped at any moment and we may be sure that the wattage is well chosen for every exposure time and that, at the same time, the exposure is shorter than with normal load—thus maximum efficiency.

<sup>2</sup> A. Bouwers, Verkürzung der Aufnahmezeit durch eine neue Belastungsmethode. Fortschritte d. Geb. d. Röntgenstr., 1933, XLVII, 703

Figure 3 shows one of the newest apparatus for universal diagnostic work, which has, amongst several special features, this automatically decreasing load feature

tube has been to such an extent that now all radiographic and radioscopic work may be done by it. The difficulty has up to now been the "cooling." The freely rotat-

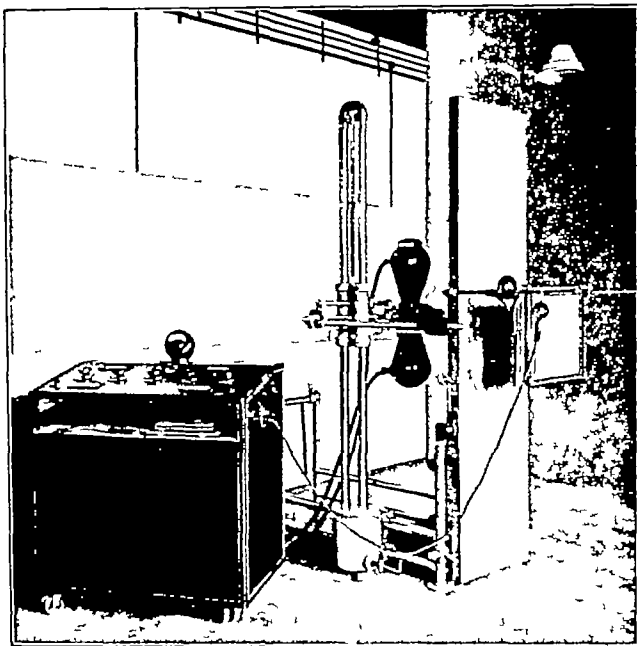


Fig 3 New x-ray apparatus for universal diagnostic work. Voltage generator with new gas-valves and switch-table in one. Automatic loading system as described.



Fig 4 Principle of the new rotating anode with "cooler." Heat dissipation by radiation.

*C Rotating anode tube with "anode cooling"*—Rotating anode tubes give essentially better radiographs than tubes with stationary anodes. The rotating anode tube is used more and more for quickly moving objects and the improvement (eight times the load as compared with a stationary anode tube, both focal spots being equal in size) is so obvious that one is inclined to ask why its use is not even more general than it has heretofore been.

The recent improvement of the Rotalix

ing copper body will, after a certain number of exposures, reach a high temperature, and the dissipation of heat through the bearings, through radiation and through the surrounding gas molecules, is, of course, restricted. The construction shown in principle in Figure 4 brought the desired solution.

A number of cylindrical extensions of the rotating body have artificially blackened surfaces. Another set of cylinders, also with artificially blackened surfaces, has a good heat contact with the "cooling body."

Heat radiation from the anode cylinders is, at about  $450^{\circ}\text{C}$ , sufficient to transfer the energy of radiosopic work with inter-

chest films, and has, nevertheless, a fine focal spot

*D* A new high voltage rectifier—High

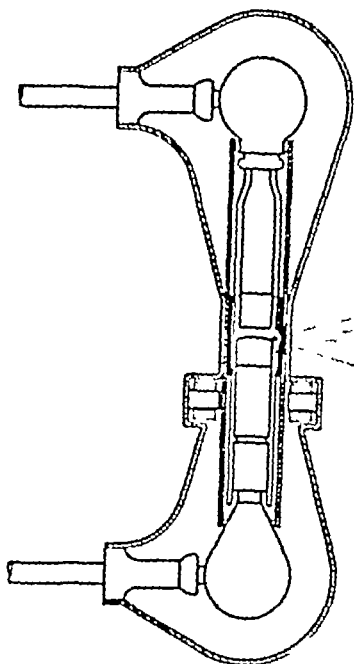


Fig. 5 Shock proof and ray protected "Rotalix" tube

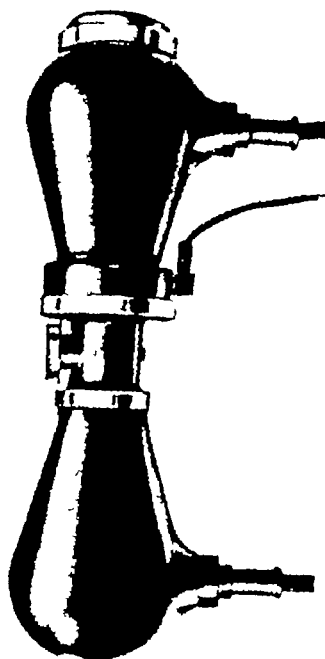


Fig. 6 Photograph of ray protected Rotalix tube of Figure 5

mittent radiographs to the fixed cylinders of the cooling body. The latter may, of course, be a radiator or a water reservoir or also a "mass cooler," as indicated in Figure 5.<sup>4</sup> This "mass cooler" has the considerable advantage of avoiding liquids or ventilators, the energy being momentarily stored up in the mass of the cooler with great heat capacity and then the mean energy is dissipated by convection and radiation. This new cooling system is now also applied in all Metalix shock-proof tubes.<sup>5</sup>

Figure 6 shows the shock-proof rotating anode tube, capable of doing all diagnostic work. It withstands the heaviest charge necessary for the very short long-distance

<sup>4</sup> A Bouwers, Eine Röntgenröhre mit drehbarer Anode und "Anodenkühlung." Fortschr. a. d. Geb. d. Röntgenstr., 1933, XLVII, 232

<sup>5</sup> A Bouwers, Ueber eine neue Anodenkühlung für Röntgenröhren. Fortschr. a. d. Geb. d. Röntgenstr., 1932, XLVI, 718

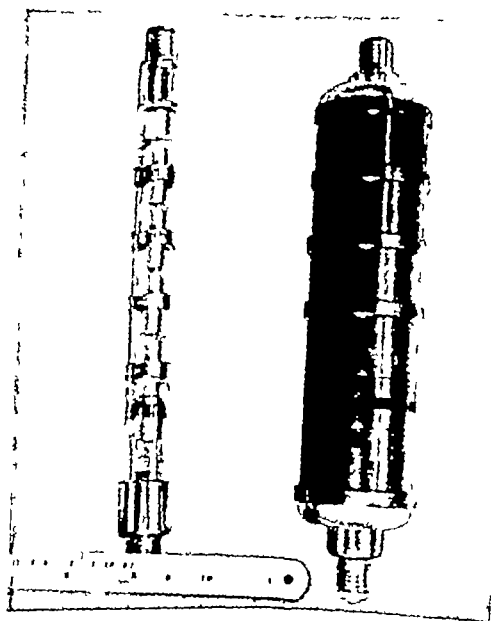


Fig. 7 New mercury high voltage rectifiers without and with condensers

vacuum rectifiers have contributed to a large extent to the progress of radiology, but they have disadvantages, as will be more clearly shown at the discussion of a new apparatus, which will be reported on later. What we have been trying to obtain are chiefly the following features: small voltage drop, large anode current, and low heating energy. These features are obtained with a new rectifier with gas discharge, of which a description will be given separately. The valve consists of a series of small discharge tubes containing mercury vapor, the first of which (cathode end) contains a filament for producing the electrons necessary to maintain the discharge.

To make sure that each step of the valve has equal voltage, condensers are arranged around them in series, each condenser in parallel with one of the steps. Figure 7 shows a valve without and with condensers.

Valves up to 200 K V have been constructed of reduced dimensions with practically no voltage drop, even at currents of the order of 1 ampere and a heating energy of a few watts only.

*E A new x-ray unit of very small dimensions*—Recent improvements have made it possible to build Metalix tubes, with practically an all-metal cylindrical exterior wall of very small dimensions. The metal wall may also be grounded with the great advantage that the tube may be put in contact with grounded parts of the transformer. In studying the way in which this feature can be best made use of, we arrived at the design shown in Figure 8. The iron of the transformer is arranged in a new way round the tube, as indicated. The primary and the secondary windings are in the circular opening, cut in the iron.

In this new transformer the electrical field between iron and secondary windings has no maxima as in ordinary transformers, so that sharp edges of an iron core are entirely avoided. Furthermore, no room is wasted, as will be seen from the drawings, so that weight and dimensions are as small as they possibly can be. The

anode of the tube is in air, so its energy is not warming up the insulating material as it does in apparatus with tubes immersed

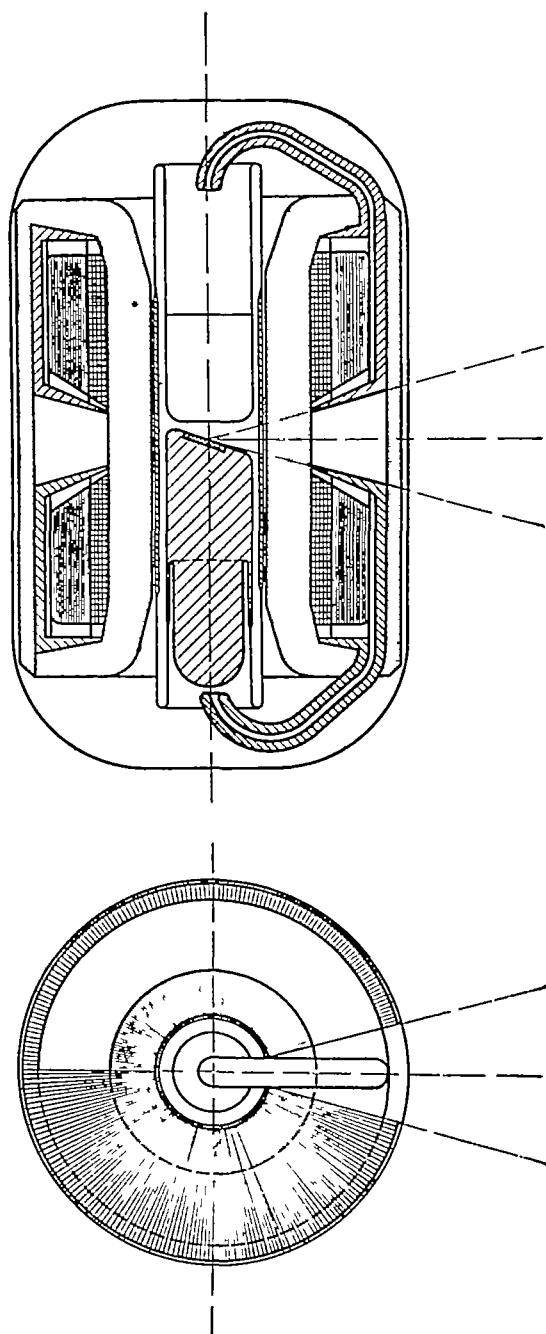


Fig 8 Principle of new compact x-ray unit

in oil. The focus of the tube is in the center of the apparatus, which has proven to be of considerable advantage. Experiments show that the tube may even be



held in the hands during exposure, as with small movements the center of gravity tends to keep steady.

Two types of this new apparatus have

of a transformer, a rectifier, and a condenser in series. The condenser is charged to a voltage which is the maximum of the transformer voltage. The so called Grein-

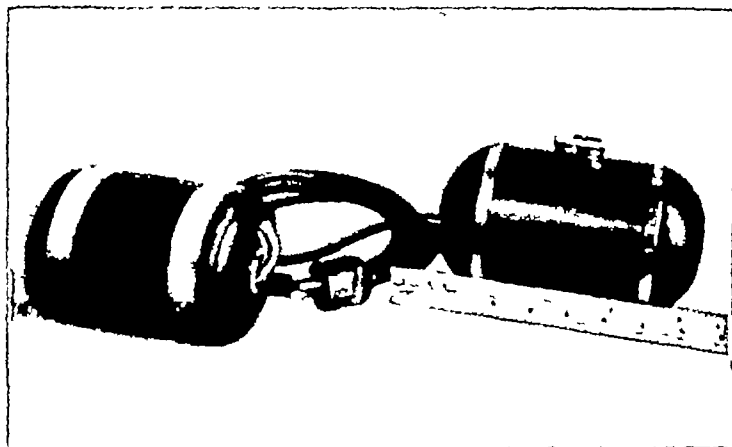


Fig. 9 Photographs of the smallest x-ray unit without and with mantle



Fig. 10 Chest film taken with new unit

been developed so far—a small dental type, weighing only about 12 pounds, and a portable type, weighing about 17 pounds. A more detailed description will be given separately, but Figures 9 and 10 show some further idea of the new apparatus.

*F* A new high tension generator for very high voltages—Well-known in therapy is the so-called Villard circuit, consisting

acher and Witka circuits are, so to speak, only combinations of this Villard circuit. Now, consider the voltage on the valve of a Villard circuit. It is alternating and varying from zero to double the transformer value. Starting from this alternating tension, we may again build up a sort of Villard circuit with another valve and a condenser, provided we remember

that the cathode of the valve becomes only positive with respect to the anode. The new condenser will then be charged up to

double the transformer tension and on the new valve we will find again a tension, varying between zero and the double of the

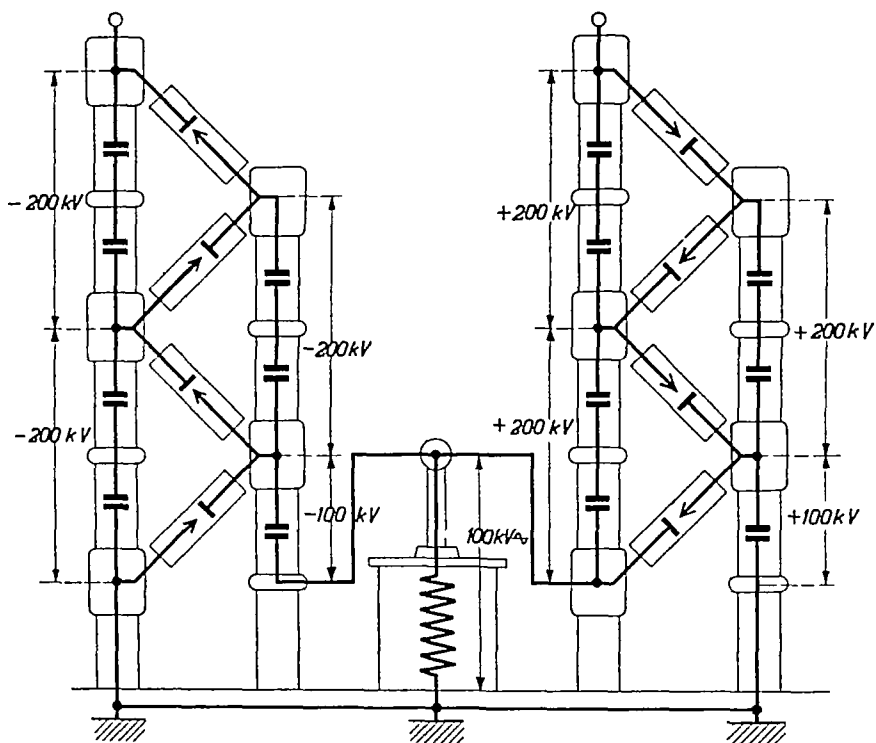


Fig 11 Principle of cascade high voltage generator

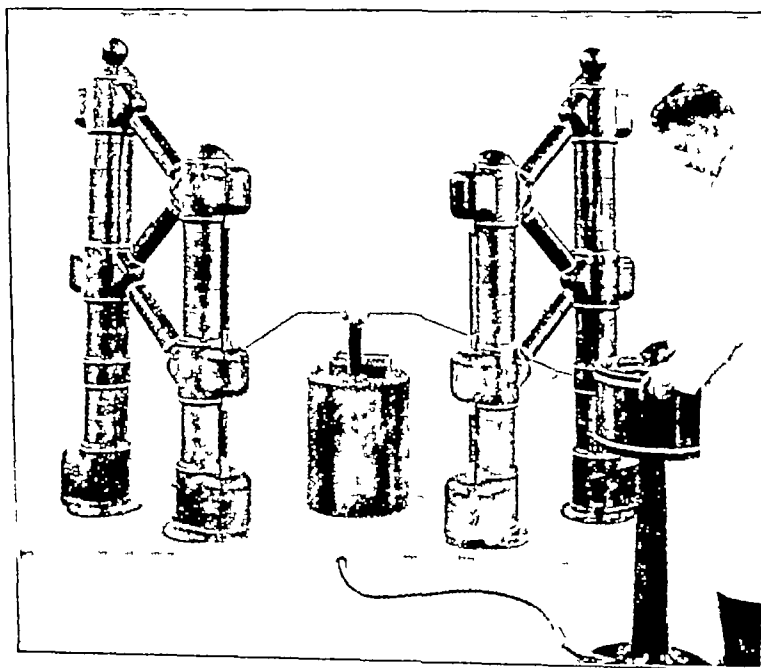


Fig 12 Photograph of cascade high voltage generator as shown in principle by Figure 11

held in the hands during exposure, as with small movements the center of gravity tends to keep steady

Two types of this new apparatus have

of a transformer, a rectifier, and a condenser in series. The condenser is charged to a voltage which is the maximum of the transformer voltage. The so-called Grein

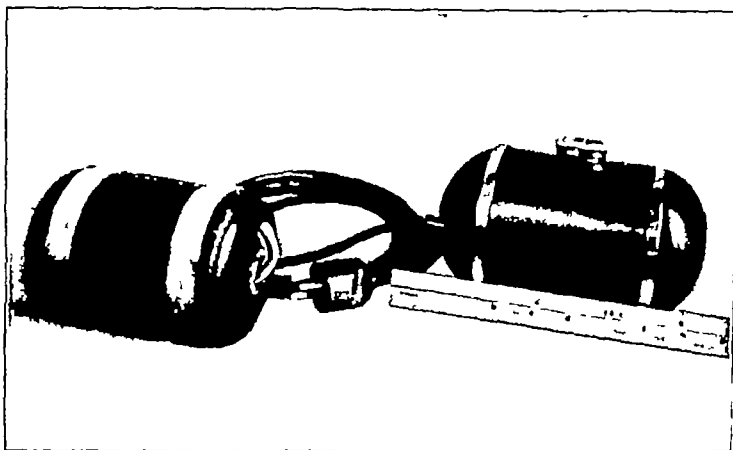


Fig 9 Photographs of the smallest x-ray unit without and with mantle

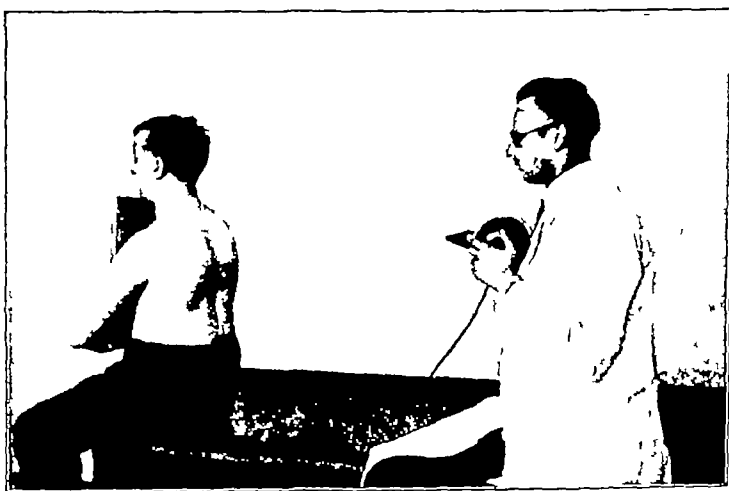


Fig 10 Chest film taken with new unit

been developed so far—a small dental type, weighing only about 12 pounds, and a portable type, weighing about 17 pounds. A more detailed description will be given separately, but Figures 9 and 10 show some further idea of the new apparatus.

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system it was, however, essential to possess new high voltage rectifiers. This was one of the reasons for our developing the new

ments. One set was developed with accumulator batteries and automatic charging-up, but also a set with small insulated

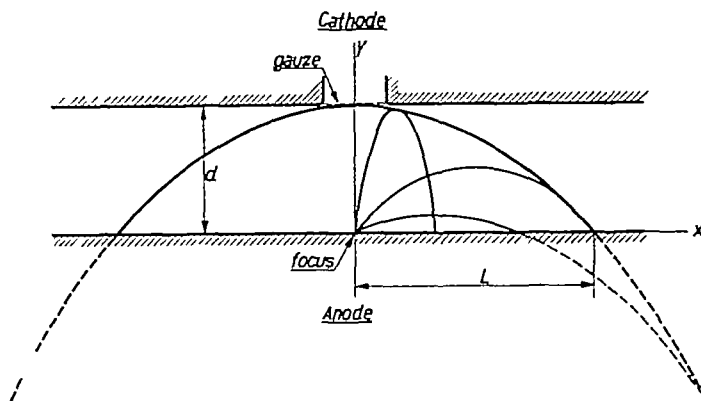


Fig 15 More tracks of secondary electrons and the enveloping paraboloid

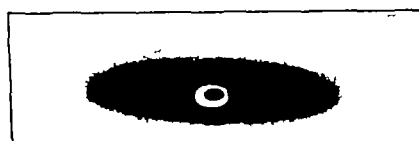


Fig 16 Pinhole camera film showing the "limited reach" of secondary electrons, as described

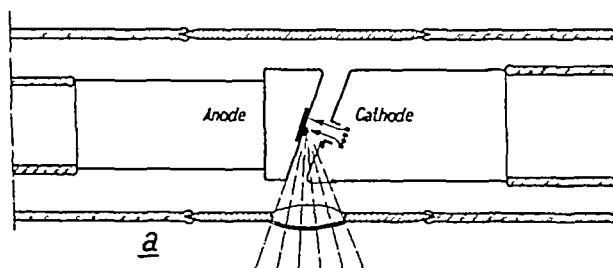


Fig 17-4 Application of the principle of "limited reach" to an x-ray tube. The lower part of the cathode is very thin

valves described above (D). It is obvious that the large anode current and the low voltage drop are of great importance, for the instantaneous value of the load currents in the valves near the transformer is many times larger than the currents used through the tube. Also, a low heating energy is of great importance, for now small batteries of accumulators may serve the few watts for heating the fila-

motor-driven generators, as is seen on Figure 12. Both solutions have the advantage of avoiding highly insulated transformers, which would be fatal for the size of the set.

A set up to 800 K V was developed with a total height of only 8 feet and recently we succeeded in building a complete 400 K V set in a shock-proof form, complete with a tube which may be placed in

transformer tension So we can go on, as is shown in Figure 11 It is obvious that an advantage of this system is the pos-

forgotten Recently Cockroft and Walton<sup>7</sup> in their report on their brilliant experiments on atom-splitting, gave a some-

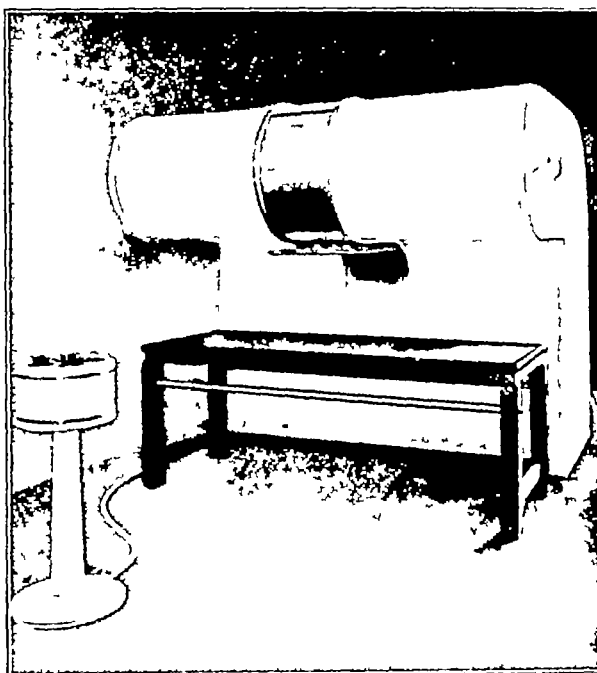


Fig 13 Shock proof high voltage generator and tube for 400 K V System of Figures 11 and 12

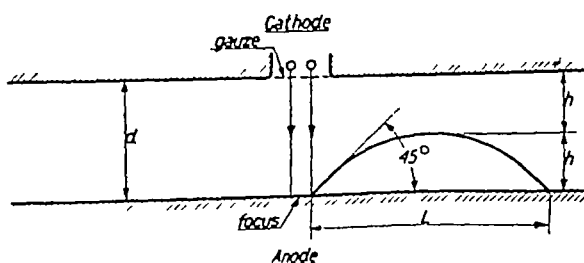


Fig 14 Showing the principle of 'limited reach' Large anode and cathode surfaces Track of secondary electron starting with an elevation of  $45^\circ$  Longest possible track

sibility of extending the voltage by new units The construction is such that this extension is easily possible

It should be said here, that an early paper of Greinacher,<sup>6</sup> as long ago as 1921, contains in principle the essentials for this system, which somehow seem to have been

<sup>6</sup> Greinacher, Bull d Schweiz Elektrot Ver, 1920, XI, 59

what difficult description of a high tension apparatus, which is also a modified application of this new system They apparently also found the system independently of Greinacher, whom they did not mention

For the practical solution of this new

<sup>7</sup> J D Cockroft and E T S Walton Proc. Roy Soc. 1932 No 136 p 619

emitted by the focal spot will be attracted toward the anode by the electrical field. If anode and cathode have large parallel surfaces (Fig 14), the electrical field is very simple and similar to the field of gravitation of the earth. We know from elementary mechanics that a bullet starting with an elevation of  $45^\circ$  has the largest reach and in our case of secondary electrons, it can be shown by elementary calculation that the maximum reach of a secondary electron is double the distance between cathode and anode. Therefore, to avoid secondary electrons in the tube, it is sufficient to give the cathode and anode surface a diameter which is at least four times the distance. Every electron follows a parabola and the envelope of all the parabolas forms a paraboloid of rotation, a section of which is shown in Figure 15. The limited surface, covered by secondary electrons, is shown in Figure 16, which is a pinhole camera picture of the anode. The focal spot has been covered with a piece of lead after a short exposure, to avoid too great density. The diameter of the covered area is exactly as calculated above and the picture, therefore, an experimental proof of the theory.

An almost equally simple calculation shows that there is also a definite "limited reach" in the case of two spherical elec-

trodes. Figures 17-A and 17-B show the practical application of the two cases schematically in high voltage tubes. Application of this new principle made it possible to build a Metalix tube which is only slightly larger than the Standard 200 K V type for tensions up to 450 K V and there is no reason why a reasonable increase in size should not bring a tube for tensions up to 600 K V or more.

The protection problem with such tubes becomes of vital importance. It is, however, possible to accomplish sufficient protection in a comparatively simple manner. Figure 18 shows how protection is acquired equivalent to 15 mm of lead in a 400 K V tube. The figure is, I think, almost self-explanatory. The cylindrical part in the anode is lead. It is outside the vacuum and the thickness is decreased so as to make the path of the x-rays through the lead equal to about 15 mm everywhere.

At last, Figure 19 shows a commercial 400 K V tube with full x-ray protection.

I think that this type of tube, together with the generator just mentioned, can be easily worked out if biologic reasons should demand, to an artificial source  $\alpha$  of radiation, which is ray- and shock-proof and so small that it may be placed in almost any ordinary room.

any ordinary room and which is shown in Figure 13

*G Self-protected Metalix tubes for 400*

In Metalix tubes their influence is restricted on account of the metal center part, which withstands the bombardment of secondary

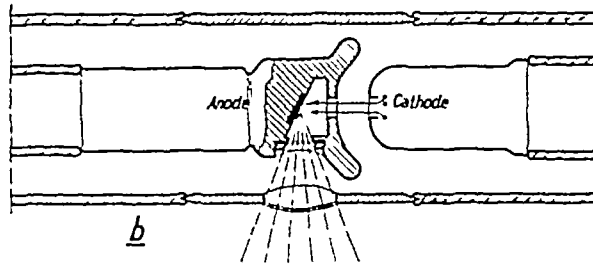


Fig 17-B Another application of the same principle

*K V and more*—One of the difficulties encountered with x-ray tubes for very high voltages lies in the secondary electrons. They charge up insulated parts of the tube negatively. They may cause heat (each electron carries an amount of energy  $\frac{1}{2} mv^2 = eV$ ) and ionization, electrolysis in the glass and also x-rays

electrons fairly well, but for very high tensions it has proven necessary to avoid them. This is done by the new "principle of limited reach,"<sup>8</sup> which may be simply explained by referring to Figures 14 and 15. Every secondary electron

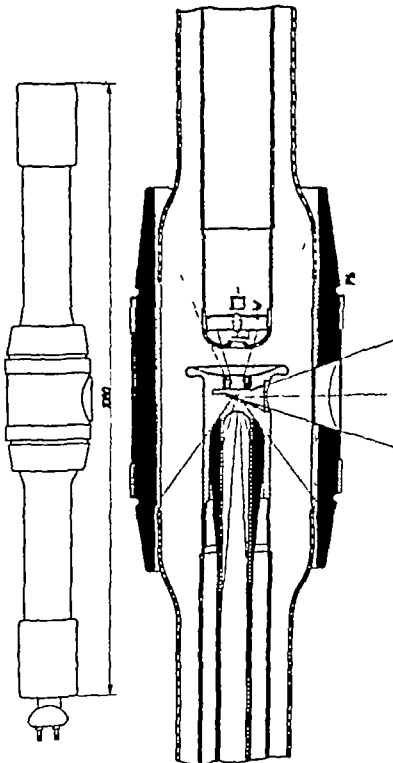


Fig 18 Showing how x-ray protection is obtained in high voltage Metalix tubes up to 500 K V

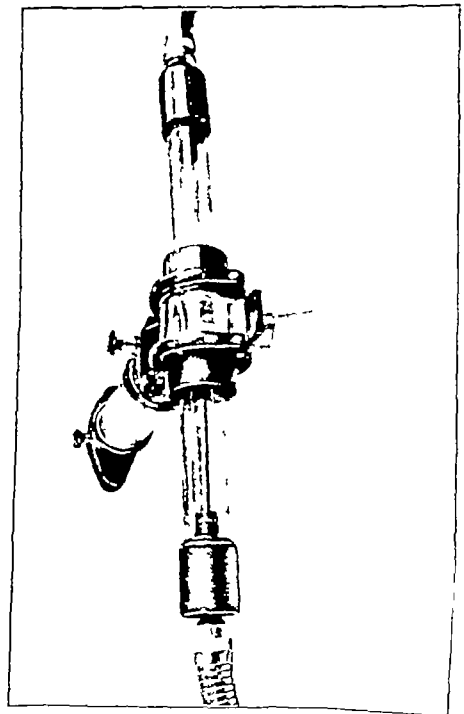


Fig 19 Metalix tube with x-ray protection for 400 K V mounted on stand

<sup>8</sup> Bouwers and van der Tuuk. Secundaire Electronen in Röntgenbuizen. Physica 1932 XII, 274

emitted by the focal spot will be attracted toward the anode by the electrical field. If anode and cathode have large parallel surfaces (Fig 14), the electrical field is very simple and similar to the field of gravitation of the earth. We know from elementary mechanics that a bullet starting with an elevation of  $45^\circ$  has the largest reach and in our case of secondary electrons, it can be shown by elementary calculation that the maximum reach of a secondary electron is double the distance between cathode and anode. Therefore, to avoid secondary electrons in the tube, it is sufficient to give the cathode and anode surface a diameter which is at least four times the distance. Every electron follows a parabola and the envelope of all the parabolas forms a paraboloid of rotation, a section of which is shown in Figure 15. The limited surface, covered by secondary electrons, is shown in Figure 16, which is a pinhole camera picture of the anode. The focal spot has been covered with a piece of lead after a short exposure, to avoid too great density. The diameter of the covered area is exactly as calculated above and the picture, therefore, an experimental proof of the theory.

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## THE EFFICIENCY OF X-RAY STEREOSCOPY AS INFLUENCED BY THE METHOD OF TRIP OF THE TUBE

By PAUL M. ANDRUS, M.D., F.R.C.P. (Can.), and A. HAMBLETON, M.A., B.Sc., London, Canada

From the Mara Research Laboratories,<sup>1</sup> at The Queen Alexandra Sanatorium

IN a former publication (1) we have analyzed the relation of the position of the x-ray tube to the resultant sharpness of film images. It was shown in that study that for the attainment of a given degree of sharpness, a saving in energy of up to 22 per cent is possible by the correct positioning of the tube, as opposed to commonly used positions. The data there presented relate mainly to *single* exposures with the focal spot centered over the film. The correct method of placing and tripping the tube for *stereoscopic* exposures, from the standpoint of obtaining maximum sharpness, is, however, also shown, and is repeated for the convenience of the reader (B, Fig. 7).

The matter of stereoscopic agreement of the images was, however, not dealt with in the previous paper, and it is with this phase of stereoscopy that the present study is concerned. This paper thus aims to be supplementary to the foregoing study in presenting the effects of tube position for the special case of stereoscopic exposures, with special reference to the agreement of the stereoscopic images.

The question of the desirability or necessity of tilting the tube between stereoscopic exposures is also important to the practising roentgenologist. Some manufacturers offer, while others do not, facilities for such tilting. The roentgenologist must make a decision in the face of these conflicting recommendations, as to whether or not he should make expenditures for such a purpose.

### NATURE OF STEREOSCOPIC ERRORS

The nature of the errors in stereoscopy which are to be examined will be clear

from Figures 1, 2, 3. The object shown in these figures is thin and parallel to the film, a condition chosen because it simplifies the point to be discussed. In Figure 1 we have the desirable ideal condition in which the x-rays proceed from a true point, and it will be seen that the images cast on the films from the two stereoscopic tube positions are identical. In the x-ray tubes in common use, however, the rays proceed from an appreciable *area*—the focal spot—which lies at an angle to the surface of the film. As a result of these two factors the images cast from the two stereoscopic tube positions are no longer identical. In Figure 2 it will be seen that the image (marked *I*) from one tube position is much larger than that from the other, i.e., the images undergo different *degrees of distortion*. The penumbral shadows (marked *P*) which determine the degree of sharpness of the images are also different from the two tube positions. Obviously, stereoscopic agreement can be no better than the geometric agreement of these two images.<sup>2</sup>

In Figure 3 the tube is so placed and so tilted during the trip that from each of the two positions the central ray of the tube travels toward the center of the object to be radiographed. It is clear from the figure that the images much more nearly approximate each other both in size and in degree of sharpness than they do under the conditions depicted in Figure 2. Perfect stereoscopic agreement is possible only when the unavoidable distortion and unsharpness of the images, due to the characters of the focal spot, are the same from the two tube positions.

Data concerning the efficiency of the

<sup>1</sup> Assisted by The National Research Council of Canada

<sup>2</sup> The difference in size of the images resulting from the thickness of an object is of course an essential part of stereoscopic projection.

stereoscopic reproduction which results from each of several methods of tripping the tube will be presented herewith. A

of the images will be correspondingly different. In cases in which the focal spot of the tube is elliptical in shape, these

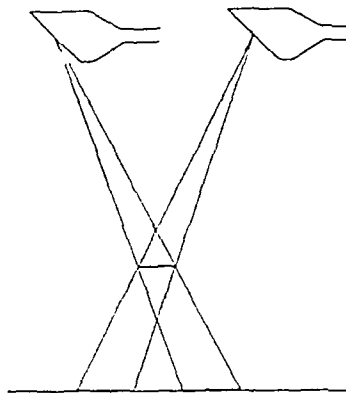


Fig 1 Perfect stereoscopy resulting from a point source of radiation

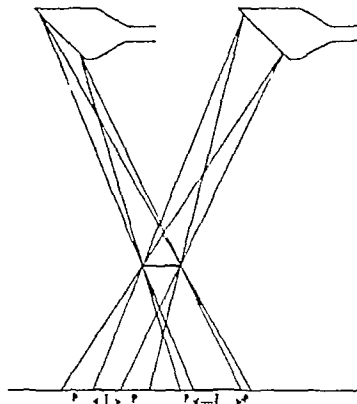


Fig 2 Imperfect stereoscopy resulting from the use of a focal spot area

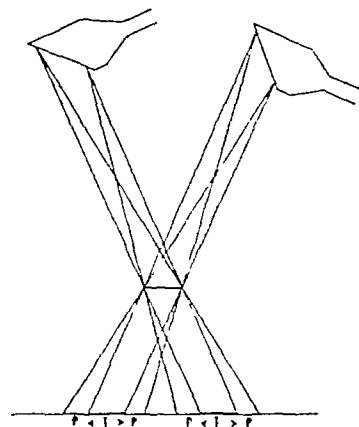


Fig 3 Correction of imperfect stereoscopy by tilting the tube

brief outline of the methods used to obtain these data follows, the lengthy mathematical calculations being omitted.

#### THE MEASUREMENT OF STEREOSCOPIC ERRORS

The errors in stereoscopy to which reference has been made can most easily be measured in terms of the change in the effective size of the focal spot that results when the tube is moved from the first to the second stereoscopic position. As described at length in an earlier paper, and illustrated in Figure 4 of this article, an object is radiographed by a focal spot whose effective size can be found by projecting in the direction of the object, parallel lines from all points around the focal spot onto the film. Thus from the tube position *A* in Figure 4, the point *O* would be radiographed with a focal spot whose effective size is *A'*, while from tube position *B* it would be radiographed with an effective focal spot size of *B'*. Thus although the actual focal spot size and slope at *A* and *B* are identical, it is apparent that the *effective* focal spot size with which the object *O* is radiographed is quite different from the two positions, and the consequent distortion and unsharpness

effective focal spot shapes (or focal spot projections) are also elliptical, as shown at the lower edge of Figure 4, and at *C*, where they have been superimposed for clarity of description. Toward the margin of the film, as described elsewhere (1), the elliptical focal spot projections from the two tube positions differ not only in size but also in the slope of their axes, so that the focal spot projections fail to agree in the general manner indicated by the ellipses in Figure 5. It is the extent to which these effective focal spot sizes (or focal projections) fail to coincide which determines the measure of the stereoscopic error to be examined.

The *actual* sharpness and distortion of an image (in contra-distinction to the potential or theoretical characters) depend, in addition, upon factors which are beyond the scope of this article, such as the *actual* size, shape, and slope of the focal spot, and the ratio of the target-object to the object-film distance. Contrast and photographic visibility are further factors which influence the apparent definition or sharpness of the image. We are here concerned only with the *relative* efficiency of the various methods of placing and tripping the x-ray tube for stereoscopic exposures.

The methods for calculating the size and slope of the focal spot projections are detailed in the earlier article (1) Referring

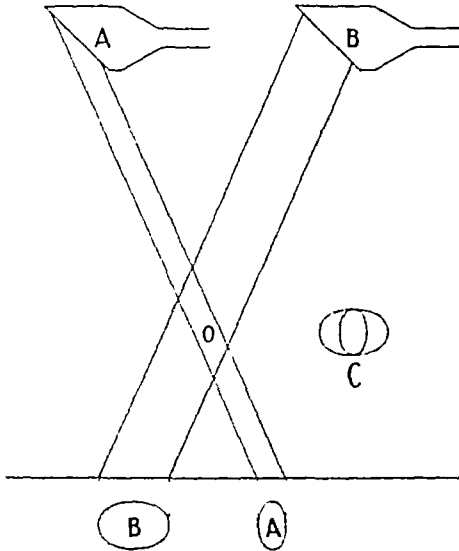


Fig 4 Changes in the effective size of focal spot with which an object is radiographed from two stereoscopic tube positions

to Figure 5, where the two ellipses represent the focal spot projections from the two stereoscopic tube positions (superimposed for convenience of description), and  $XY$  represents the direction of a linear structure to be radiographed, it is shown in that article that the effective size of the focal spot with which this linear structure is radiographed is given by the dimension  $AB$  in the case of one ellipse and by  $CD$  for the other ellipse. It will be noted that these dimensions  $AB$  and  $CD$  are the distances between parallel tangents to the focal spot projections,<sup>3</sup> and that the tangents run parallel to the edge being radiographed. The difference between these two dimensions  $AB$  and

<sup>3</sup> The distance between parallel tangents to an ellipse is given by  $\sqrt{L^2 \sin^2 \theta + S^2 \cos^2 \theta}$  where  $L$  and  $S$  are the major and minor axes of the ellipse, and  $\theta$  is the angle between the tangents and the major axis of the ellipse.

The other formulae used in calculating the results given in this article are detailed in the earlier paper (1). Certain corrections must be applied to these formulae when the tube is tilted or rotated from its normal position, the nature of these corrections will be obvious to those familiar with projectional geometry.

$CD$  is the measure of the stereoscopic error for the point  $P$  on this linear structure, since this dimension governs the difference in sharpness and distortion between the two stereoscopic images.

Since in practical radiography the object to be examined will usually contain structures running in every possible direction, the stereoscopic error must be evaluated with reference to all possible directions of the linear structures. The calculation of the differences between parallel tangents to the two projection figures in all directions, however, proved to be an impossible mathematical task. It was necessary, therefore, to substitute a method of finite differences, and the calculation has been made for ten-degree intervals around the projection figures. By this means a fair average figure for the stereoscopic error at any point on a film may be evaluated by direct calculation. Since the stereoscopic error is widely variable over different parts of the film, we have presented figures for the average stereoscopic error at selected points on the film, namely, the center, the corners, and the mid-point along each edge.

#### TYPES OF STEREOSCOPIC TRIP

Since the object of this article is to compare the efficiency of various types of stereoscopic trip, let us now consider the most commonly used methods of tripping the tube, as depicted in Figure 6, wherein the dotted line indicates the direction of the central ray of the tube, while  $O$  indicates the central point of the object being radiographed.

At  $A$  is shown the commonly used longitudinal trip of the tube (also shown in Figures 1, 2, and 4 of this article). At  $B$  the tube is so placed and tilted during the trip that from both tube positions the central ray of the tube passes through the point  $O$ . As a result of the conditions shown at  $B$ , the stereoscopic errors at the point  $O$  are practically zero, as pointed out earlier (Fig 3). In  $C$  and  $D$ , Figure 6, is shown the end view of the tube, the tube

being tripped laterally, *i e.*, at right-angles to the long arms of the tube, at *C* is shown the plain lateral trip, while at *D* the tube

of sharpness and the same degree of distortion of the image, so that the two visual images fuse perfectly and perfect stere-

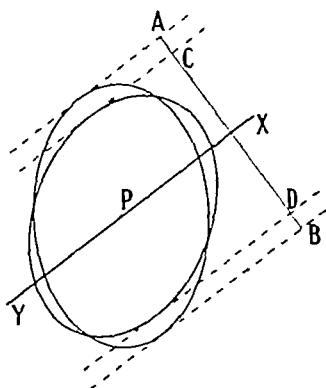


Fig 5 Difference in the effective focal spot sizes (*A B* and *C D*) with which the point *P* on the linear structure *X Y* is radiographed from two stereoscopic tube positions

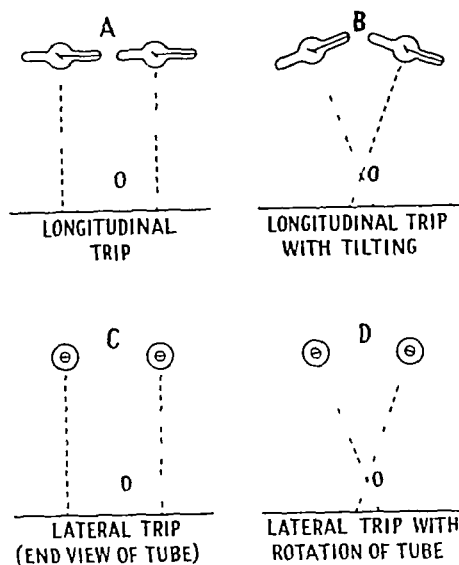


Fig 6 Illustration of methods of tripping the tube as described in the text

is so placed and rotated on its long axis during the trip that the central ray is projected in the direction of the point *O* from each of the tube positions

Using the four types of trip described above, Table I gives the average stereoscopic error at selected points for an object of such size that it could just be completely radiographed upon 14 x 17 inch stereoscopic films. The other conditions used for the calculations are that the target-film distance is 30 inches, the object-film distance is 6 inches, the anode slope is 45° to the film, the focal spot is elliptical in shape, and the tube is tripped 2½ inches, the target being equidistant from the center of the film at each tube position. The central ray projection of the tube is assumed to have a diameter of 100 units, and the figures given in Table I indicate in terms of these units the *difference* in the effective size of the focal spot with which the given points on the object are radiographed from the two tube positions. Thus if the tabulated difference is zero, the change in the effective size of focal spot is also zero. On each of the stereoscopic films there is then the same degree

of sharpness and the same degree of distortion of the image, so that the two visual images fuse perfectly and perfect stere-

#### DISCUSSION OF METHODS OF TRIP

The stereoscopic efficiency resulting from these different methods of tripping the tube is shown in Table I. As noted above, the smaller the figure in these tables the better is the resulting stereoscopic agreement. The bottom row of figures gives the average efficiency for nine points on the film, the lower three positions in the table occurring twice.

It is apparent from these tables (Column 3) that much the best stereoscopic agreement is obtained by tripping the tube in its long axis, together with an appropriate degree of tilting, as illustrated in *B*, Figure 6.

It is important at this stage, however, to recognize that stereoscopic agreement is closely related to attained film sharpness. As the sharpness of the images approaches perfection, the significance of stereoscopic differences must become negligible. The

TABLE I — DIFFERENCE IN STEREOSCOPIC PROJECTION USING VARIOUS TYPES OF TUBE TRIP

(The figures given are percentages of the central ray projection)

Film Position of the Image	Longitudinal Trip	Lateral Trip	Longitudinal Trip with Appropriate Tilting	Lateral Trip with Appropriate Rotation
Cathode center	7	4	0	0
Film center	7	7	0	0
Anode center	7	6	0	0
Cathode corner	14	9	3	5
Anode corner	10	7	2	7
Midlateral edge	14	8	2	5
Average over entire film	12	7	1 6	3 8

TABLE II — TOTAL ANGLE THROUGH WHICH THE TUBE SHOULD BE TILTED OR ROTATED DURING THE STEREOSCOPIC TRIP

(Applicable to both 45° and line focus tubes)

Target to Center of Object Distance, Inches	Length of Tube Trip in Inches									
	1½	2	2½	3	4	5	6	8	10	12
18	4° 45	6° 20	7° 55	9° 30						
24	3° 33	4° 45	5° 57	7° 10	9° 30					
30	2° 52	3° 45	4° 45	5° 42	7° 35	9° 30				
36		3° 10	4° 0	4° 45	6° 20	7° 55	9° 30			
48			3° 0	3° 33	4° 45	5° 57	7° 10	9° 30	11° 30	
60				2° 52	3° 45	4° 45	5° 42	7° 35	9° 30	11° 20
72					3° 10	4° 0	4° 45	6° 20	7° 55	9° 30
84						3° 25	4° 5	5° 25	6° 47	8° 10

stereoscopic differences as here defined, relate to different methods of tripping the tube. They may or may not be important in the visualization of a given stereoscopic pair, depending upon whether the actual distortion and unsharpness in the images is negligible or important in degree.

Returning then to our selection of Column 3 in Table I as representing the best agreement between stereoscopic images, it will be observed that this method of placing the tube is in conflict with our previous recommendations, *i e.*, that the long axis of the tube should always be placed along the shortest dimension of the film in order to attain the maximum sharpness inherent in the focal spot in use. Since then as above, sharpness of image should take precedence over stereoscopic agreement, it would seem that the method of tripping the tube which gives the next best agreement should be adopted. This occurs in Column 4, Table I, the tube

being tripped in its own lateral axis along the long axis of the film and rotated between exposures as illustrated in *D*, Figure 6. This, then, is to be recommended as giving the best stereoscopic agreement consistent with efficiency as to sharpness and distortion of images.

If facilities for simply rotating the tube between exposures are not available, the next best stereoscopic agreement (Column 2, Table I) results from the same method of trip but without rotation of the tube between exposures. The commonly used method of tripping the tube in its own long axis and without tilting (Column 1, Table I) gives much the poorest stereoscopic agreement of all positions, as well, incidentally, as the poorest film sharpness. The 12 per cent error in agreement resulting from this method of trip may be expected to be within the visual range. However, we should repeat that these differences relate only to the *relative*

efficiency of different methods of tripping the tube and that if the actual sharpness of the images is excellent, the differences in stereoscopic agreement will not be important

We are not yet in a position to define for practical use the actual geometric limits of visibility

For convenience of the operator, the angle through which a tube must be tilted or rotated in order to project the central ray to the center of the object is given in Table II for various target-to-center-of-object distances and tube trips. This value is approximately contained in the formula

$$\text{Tan angle} = \frac{\text{Length of trip}}{\text{Target to center of object distance}}$$

For stereoscopic exposures of long bones, such as the spine, wherein the trip is to be made at right-angles to the long dimension of the bone, the correct method of placing and tripping the tube is shown in C, Figure 7. This gives the greatest attainable uniformity of sharpness over the entire length of the image, but the tube should also be tilted when possible between these exposures

#### STEREOSCOPIC EXPOSURES WITH LINE FOCUS TUBES

With line focus tubes, the effective focal spot size over the various parts of the film is always less uniform than with the 45° slope of anode. As pointed out earlier (2), both the steeper slope of the anode surface to the film and the more rectangular shape of focal spot in the line focus tube are contributory factors in producing this undesirable result. However, we are of the opinion that the increased tube capacity made possible by the line focus principle more than compensates for this defect. Correct positioning and tripping of the tube, as given in this and earlier publications (1, 2), are more important in the case of line focus tubes than with 45°

anode tubes, since with the former a greater improvement in radiographic reproduction is attained by using the correct technique

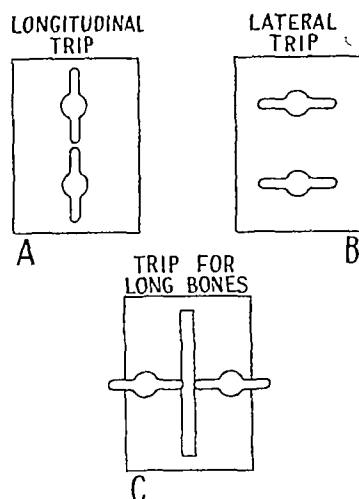


Fig 7 Plan view of methods of placing and tripping the tube for stereoscopic exposures

#### SUMMARY AND CONCLUSIONS

1 The principles governing the agreement of images in x-ray stereoscopic pairs, together with the relative efficiency of different methods of tripping the tube, are analyzed and tabulated

2 The data are supplementary to a previous analysis of the most efficient position of the x-ray tube with reference to the film (1), but for the special case of stereoscopic exposures

3 The best stereoscopic agreement (consistent with efficiency as to sharpness and distortion of images) is obtained by tripping the tube in its own lateral axis along the long axis of the film, while at the same time rotating the tube so that the central ray is in each case projected to the center of the object to be radiographed (D, Fig 6)<sup>4</sup>

4 Stereoscopic agreement is 3 per cent better when the tube is so rotated than in

<sup>4</sup> See text for necessary exception in the case of long bones

the case of the same trip without rotation, and should be attained, therefore, when mechanically feasible. In the presence of satisfactory sharpness of film images, however, this improvement in agreement is probably not within the range of visibility, and no outstanding trouble or expenditure seems to be warranted on this account at the present time.

5 Failure to place the tube correctly for stereoscopic exposures results in greater distortion and unsharpness of images than

in the case of single films, and is more marked in the case of line focus tubes than for  $45^\circ$  anodes.

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## PERFORATION OF PEPTIC ULCER FOLLOWING X-RAY EXAMINATION WITH A BARIUM MEAL

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ROENTGEN examination of the stomach with the aid of a barium meal is generally considered entirely innocuous, on which account barium studies of the stomach are employed more or less routinely and without discrimination or restriction. That this method of examination, however, is not altogether harmless is attested to by the number of cases in which radiographic investigation with a contrast medium is followed by acute perforation of a peptic ulcer. Publications dealing specifically with the subject of gastro-duodenal rupture as a sequel to the employment of the x-ray include 36 patients, 34 of whom had benign lesions and two malignant. Of the 34 perforated peptic ulcers, Panek reports eight, Eckman five, Hummelman four, Bittrolff three, Amberger, Colmers, and Nussbaum each two. Single instances are recorded by Ein Waldt, Frankenthal, Hijmans van den Bergh, Lang, Meijer, Rosenthal, Steiger, and Uthi. Of the two carcinomatous ulcers which perforated following x-ray examination, one is reported by Lepennetier and Deruas and the other by Rovida. That the number of cases published under appropriate titles is by no means representative of the actual incidence is indicated by the frequency with which perforation following x-ray is mentioned incidentally in cases presented for other reasons. Casual mention of rupture occurring shortly after roentgenography is found, for instance, in the articles of Brütt, Dahm, Falta, Fermaud, Finsterer, Speck, and Wolfson and Gray, dealing primarily with other phases of perforated ulcer. Furthermore, there is evidence to show that experience with this accident is not confined to only a few but that it has been observed by many. Eckman states that after citing

his five cases at a regional meeting of the American College of Surgeons, "Numerous admissions of such catastrophes were forthcoming." I have met with the same response at meetings where I have had occasion to mention my own cases.

Assuming that the cause and effect relationship between perforation and x-ray examination is a definite one, the question arises as to how serious a hazard is constituted by this diagnostic procedure. The only published statistical reports upon which to base an opinion are those of Panek, Hummelman, and Eckman. Panek writes that among 36 cases of perforated peptic ulcer observed in the Second Surgical Clinic of the University of Vienna between the years 1910 and 1926, eight followed roentgen examination with a contrast medium. These eight cases are divided by the author into two groups, the first including four cases in which rupture occurred within several hours of the x-ray observation, and the second group comprising the remaining four in which perforation followed after an interval of between 30 hours and six days. If the time element in Panek's series is disregarded, it is found that 22 per cent of his perforated ulcers followed the x-ray. If the second group of perforations is eliminated because of the questionable etiologic relationship, the percentage of ruptures occasioned by roentgenography still remains high (11.1 per cent). Among 17 cases of gastrointestinal perforation treated at the Surgical Clinic of the University of Bonn, five (29.4 per cent) occurred as sequelae to a barium meal. Hummelman, who submits the above report, states that during the time the five perforations were observed a contrast medium was administered by mouth to 1,500 individuals.



No mention is made of the number of ulcer patients in this group. The statistics of the Duluth Clinic, published by Eckman, includes five perforations in a series of 522 ulcer patients examined roentgenologically, an incidence of less than 1 per cent. The total number of perforations observed during the same period is not stated. At the Cook County Hospital only four perforations have been observed following x-ray examination during the past ten years. Within the same period of time over 500 perforated ulcers have entered the Hospital and more than 5,000 unruptured peptic ulcers have been examined radiographically. Based upon these figures the percentage of perforations which follow the x-ray examination is found to be only 0.8 per cent. Approaching the question from another standpoint, the incidence of perforation following examination of unruptured ulcers is merely 0.08 per cent. Judging from our own rather large group of cases, it appears that the hazard of perforation in connection with a barium meal is attended by relatively slight danger.

In considering the factors concerned in the production of a perforation, particular stress has been placed upon manipulation and compression of the stomach during the x-ray examination. The possible damage incident to manipulation by hand is exemplified in a case recorded by Albrecht. This author relates that a man of 40, while being examined with a barium meal, collapsed behind the screen on account of pain. Operation performed within an hour demonstrated, aside from a cholelithiasis, firm adhesions which stretched between the gall bladder and the duodenum and pylorus, and were partially torn. Compression of a given portion with the aid of a *Distinktor*, increasing, as it does, internal pressure, is especially dangerous in cases in which conditions are favorable for rupture. The rôle of the *Distinktor* and similar apparatus is emphasized by Mandl. In reviewing the individual case reports one is impressed by the large proportion in which an element of obstruction existed and in

which, therefore, forceful compression was presumably employed. For instance, in connection with his third case Eckman writes "It was only after a repeated hypodermic of atropin and rather forceful palpation that a large filling defect was noted in the duodenal cap." In two of my cases (Nos. 2 and 4) the examining roentgenologist recalled having employed unusually firm pressure in an attempt to visualize the bulb. The weight of the barium is generally considered to be less important in the etiology of the perforation than manual or instrumental factors.

Assuming as correct that forceful manipulation or compression and high specific gravity of the contrast medium induce perforation, the question naturally arises, Why is the accident of relatively uncommon occurrence? In other words, what are the predisposing factors which are absent in the overwhelming majority of ulcer patients and which condition the perforation in the small minority? One factor which appears to be highly significant is the status of the ulcer, namely, whether progressive or retrogressive. When an ulcer which has been healing for a time is subjected to the trauma incident to a barium meal examination, perforation is a rather remote possibility. If the ulcer has been penetrating the gastric wall and the base is approaching the serosa, other things being equal, x-ray examination is attended by a high coefficient of danger. Active extension of the ulcer, however, does not of itself explain the occurrence of perforation, for only a small percentage of progressive cases rupture as a result of a barium meal study. In order to account for the relative infrequency of perforation following x-ray examination, even in cases in which symptoms indicate progressive penetration, it is necessary to adduce a second factor—the location of the ulcer. When the lesion is situated on the lesser curvature or posterior wall of the stomach or duodenum, its extension beyond the serosa is usually into a neighboring viscus or other structure. The result is an extra-gastric penetration rather than a perfora-

tion A posterior wall ulcer may rupture into the omental bursa, but this is a relatively rare occurrence. As a rule, it is an ulcer located on the anterior wall which perforates into the free abdominal cavity. Since only 5 per cent of all ulcers are situated on the anterior wall (Boas), barium studies can be made in about 95 per cent of the cases with active progression with little or no hazard of perforation.

In reviewing the case histories of patients who perforated following a barium meal study one is immediately impressed by the number of patients in whom an intensification of previous symptoms preceded the x-ray examination. This fact, of course, should occasion no astonishment, since the average patient seeks medical advice only when his pain no longer yields to the usual household remedies. Because roentgenography is universally considered an integral and essential part of the "work-up," in clinics and hospitals particularly, it is during the stage of active extension of the ulcer that examination is generally performed. The occurrence of an aggravation of previous symptoms is of more than casual interest, since it may indicate active extension and, therefore, potential perforation. The assumption that an intensification of the usual manifestations of ulcer is indicative of penetration toward the peritoneal coat is based upon observations in patients who perforate spontaneously. Several authors (Federmann, Finsterer, Leube, Moynihan, Ryser, and Walton) have emphasized the presence of prodromal or inaugural symptoms in cases of perforation which occurred from no apparent cause.

From the practical standpoint, it is important to identify, if possible, those patients in whom x-ray examination with barium is attended by the hazard of perforation. The two tangible factors which contribute to rupture following roentgenography are location on the anterior wall and active extension of the ulcer. With regard to determining the location of an ulcer by clinical means little can be expected. Pain referred to the back is

usually associated with posterior wall ulcer, but dorsal radiation is frequently lacking. Although tenderness and rigidity are described in connection with "perforating" anterior wall ulcers, these physical signs are generally absent until after perforation has actually occurred. Since the location of the ulcer cannot be predicted, recognition of the cases which are ill-suited for barium meal study must be based upon clinical evidences of progressive penetration. This is indicated by an intensification and increased refractoriness of the patient's usual ulcer symptoms. If x-ray examination with barium is withheld from ulcer patients with clinical manifestations indicative of penetration, the danger of perforation following roentgenography will be greatly reduced. Energetic ulcer treatment at this time will generally initiate processes of healing and render the ulcer inactive in a comparatively short period. In the stage of retrogression the x-ray procedure is attended by relatively little danger and can be more thoroughly and satisfactorily carried out. When a barium meal examination is considered essential and is undertaken in spite of the presence of prodromal symptoms, the suggestions made by Panek should be observed. This author advises, in the presence of a recent exacerbation of an ulcer, the two following precautions: (1) less barium in more fluid, (2) elimination of the *Distinklor* and only gentle palpation to aid in distributing the barium rather than to compress the stomach.

The four cases of perforation following a barium meal which came to the author's attention are summarized below. In each instance the x-ray examination was performed at a time when the ulcer was actively penetrating, as indicated by recent intensification of previous symptoms. In all four patients forceful manipulation was employed in an attempt to visualize the lesion. In two (Cases 1 and 3) the perforation was not diagnosed at the time of its occurrence and consequently operation was not performed. Failure to recognize the presence of an acute rupture was due to

the atypical clinical picture which followed the intense initial pain. The symptoms manifested in the post-perforative stage were those of mild localized peritonitis conditioned by early spontaneous closure of the hole, which limited the quantity of extravasated material (see Singer and Vaughan). It is quite likely that additional *forme fruste* perforations have followed x-ray examination but, having escaped recognition, have not been recorded.

#### CASE REPORTS

Case 1 M A, male, white, 34 years of age, entered the Cook County Hospital Oct 3, 1924, with a history of chronic ulcer symptoms extending over a period of two years. During the week prior to admission he experienced an increase in the intensity and persistency of his previous pain, and, in addition, suffered for the first time from vomiting. The following day a barium meal examination was made and after forceful compression of the stomach merely a prepyloric elongation was detected. Three hours after completion of the fluoroscopic examination the patient developed typical symptoms of perforation, which, however, were not correctly interpreted by the interne on the service. Gall-bladder disease was suspected, based mainly upon the radiation of pain to the right shoulder and predominance of physical signs in the right upper quadrant. Exploratory operation, performed Oct 18, 1924, fifteen days after the onset of violent pain, disclosed the pyloric region of the stomach to be intimately attached to the under surface of the liver. After separation of the adhesions a prepyloric ulcer which appeared to have perforated, was exposed. Contained within the adhesions was a small quantity of barium. The perforation was sutured and a gastro-enterostomy performed. The recovery was uneventful.

Case 2 G B, white man of 45, entered the Cook County Hospital on May 8, 1927, complaining of epigastric pain which had troubled him daily for a period of two

months. Prior to ten days or so before admission the pain had been readily relieved by baking soda or food, but during the one and one-half weeks before entering the Hospital the distress was not amenable to the usual measures. On May 10 the patient was radiographed with the aid of a barium meal and a duodenal deformity characteristic of ulcer was observed. An excessive amount of manipulation was employed in order to demonstrate the lesion to the satisfaction of the attending physicians and internes present. Fourteen hours after fluoroscopy the picture of an acute perforation supervened. Operation performed within an hour disclosed a hole on the anterior wall of the duodenum, with the usual type of extravasated material and exudate, unaccompanied by any barium.

Case 3 This case was reported some time ago as an example of spontaneous recovery following perforated peptic ulcer, at which time, for the sake of brevity, only that evidence pertaining chiefly to the subject discussed was mentioned. On this account the severity and refractoriness of the pain which led the patient to enter the hospital was not included in the published record, which is reproduced herein.

G J, a colored man, aged 49, admitted to the hospital on Aug 20, 1928, complained of periodic distress of an ulcerous type of one year's duration. Roentgen examination, on the morning of Aug 30, entailed considerable manipulation of the stomach in an attempt to overcome a pyloric obstruction. That evening, intolerable epigastric pain developed, shortly after which vomiting and hiccup occurred. The right upper abdominal quadrant was rigid and tender. Morphine afforded relief. Slight fever and a leukocytosis of 16,000 developed the next day, followed by rapid subsidence of symptoms and signs. Operation, performed on Sept 15, disclosed a perforation of the pylorus, securely covered over by the gall bladder, which formed the floor of the ulcer. The texture of the adhesions corresponded to the time which had elapsed since the acute

pain of sixteen days previously. The perforation was sutured and cholecystectomy and gastro-enterostomy performed. The patient recovered.

Case 4 J. A., a white man of 39, had

appearance of vomiting, he was examined roentgenologically in the routine manner. On account of a persistent pylorospasm, associated with a noteworthy degree of organic obstruction, the bulb was not readily



Fig 1 Case 4. Pneumoperitoneum due to perforation of a peptic ulcer which occurred 15 hours after x-ray examination of the stomach with barium. With the patient in the left lateral position, the air is seen to accumulate beneath the right lateral wall and to displace the liver downward. The contrast meal has passed into the colon.

suffered periodically from ulcer symptoms since 1923. Beginning about Nov 1, 1930, he noted a change in his usual symptoms, the pain becoming more intense and more persistent than formerly and it no longer disappeared following the intake of sodium bicarbonate. In addition, he suffered from frequent vomiting, a symptom which had not troubled him previously. He reported to the Out-patient Clinic on Nov 13, 1930, when a barium meal was scheduled for the following day. On Nov 14, two weeks following the beginning of the aggravation of pain and the

visualized. The attempt to force barium into the duodenum entailed an undue amount of vigorous compression.

On Nov 15, 1930, at 1 A.M., 15 hours after the fluoroscopic examination, the patient developed the typical symptoms of an acute perforation. He arrived in the hospital at 7 A.M., with classical signs of a ruptured, air-containing viscus. *En route* to the operating room the patient was fluoroscoped and films were taken (Fig 1). At the operation, performed shortly after 8 A.M., a perforation was found on the anterior wall of the duodenum near the

the atypical clinical picture which followed the intense initial pain. The symptoms manifested in the post-perforative stage were those of mild localized peritonitis conditioned by early spontaneous closure of the hole, which limited the quantity of extravasated material (see Singer and Vaughan). It is quite likely that additional *forme fruste* perforations have followed x-ray examination but, having escaped recognition, have not been recorded.

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lesser curvature close to the pylorus. For a distance about the aperture the wall of the duodenum was thickened and indurated. No barium was observed in the peritoneal cavity. The hole was sutured, covered by omentum, and a posterior gastro-enterostomy performed. The patient made an uneventful recovery and was discharged Dec 1, 1930.

### SUMMARY AND CONCLUSIONS

The relatively large number of reported gastroduodenal perforations which have occurred following x-ray examination with barium seems to indicate a cause-and-effect relationship. The number of ruptures following roentgenography as compared with the total number of perforations observed within a given period in two foreign clinics is surprisingly large (University of Vienna, 11.1 to 22.2 per cent, University of Bonn, 29.4 per cent!). These figures, based upon relatively small series, lead to the assumption that a barium meal study is comparatively hazardous. Statistics, based on extensive material at the Cook County Hospital, show that only 0.8 per cent of the total number of perforations were preceded by radiography.

The factors concerned in the production of a perforation pertain to the roentgen examination and the ulcer. The important factors in the x-ray investigation are manipulation and compression of the stomach, both manual and instrumental, while of far less significance is the specific gravity of the barium. From the standpoint of the ulcer the location and status (progressive or retrogressive) of the lesion are to be stressed. In general, only those ulcers situated on the anterior wall of the stomach and duodenum perforate into the free abdominal cavity, and posterior wall ulcers as a rule penetrate into a neighboring structure or organ. The status of the ulcer is also of import, since a healing lesion is far less liable to perforation than one which is actively extending toward the serosa.

Ulcer patients generally seek medical advice at a time when the symptoms are more severe and more refractory than usual, and it is then that x-ray examination with barium is ordinarily undertaken. There is evidence to show that an aggravation of customary ulcer symptoms indicates active progression of the lesion and may represent the prodromes of an impending perforation. It is of importance, therefore, in a patient with a history of recent intensification of symptoms, to postpone radiography whenever possible and to first institute ulcer management. If x-ray examination is deemed necessary and is carried out in spite of the presence of an exacerbated symptomatology, care should be exercised with regard to palpation and the specific gravity of the barium administered.

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Fig 3, Case 1 Roentgenogram taken Aug 11, 1928



Fig 4, Case 1 Roentgenogram taken April 20, 1929



Fig 5, Case 2 Shows same conditions and course as Case 1 (Feb 1, 1930) (Above)



Fig 7, Case 2 Roentgenogram taken Aug 21, 1930 (Below)



Fig 6, Case 2 Roentgenogram taken May 3, 1930 (Above)



Fig 8, Case 2 Roentgenogram taken Jan 17, 1931 (Below)



# CORRELATION OF ROENTGEN AND PATHOLOGIC FINDINGS IN PERTHES' DISEASE

By RAYMOND W LEWIS, M D , *New York City*

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SINCE Zemansky (1) and Lippman (2) described the pathologic findings in the femoral heads in Perthes' disease, describing each a case and reviewing the 11 microscopically examined cases pre-

duration, osteoid tissue was found growing into the granulation tissue. In one old case, of eight years' duration, solid bone was found, representing the extent of spontaneous healing. Sequestra were



Fig 1, Case 1. Massive subchondral bone and marrow necrosis in femoral head (a). Zone of granulation tissue and fibrous tissue replacement, later containing osteoid tissue and repair bone (b). Absence of narrowing of joint space indicates intact surface cartilages. Epiphyseal cartilages probably involved in this case. Note that the necrosis is far in excess of the reparative processes (Oct. 25, 1927).



Fig 2, Case 1. Roentgenogram taken March 15, 1928.

viously reported in the literature, we have been impressed by the closeness with which the roentgen findings in many cases of Perthes' disease follow the pathologic descriptions.

These authors found the outstanding features of this disease to be massive subchondral bone and marrow necrosis in the developing femoral head. The surface cartilage was intact. The condition of the epiphyseal line varied—sometimes intact, sometimes interrupted, or completely destroyed. The presence of granulation tissue was constant. In cases of moderate

found in three cases, though I must confess the distinction between massive bone necrosis and sequestrum is not clear in my mind. Zemansky calls attention to the small amount of spontaneous healing in comparison to the large area of necrosis.

Omitting all reference to, and discussion of, etiology, which controversial subject we do not care to consider at this time, Zemansky's conception of the course of Perthes' disease is as follows: necrosis of subchondral bone and marrow. The necrotic bone is readily fractured by weight-bearing, with resultant deformation of surface contour. Repair is slow, by means of fibrous tissue replacing the bony fragments. A small amount of osteoid tissue is formed



Fig 3, Case 1 Roentgenogram taken Aug 11, 1928



Fig 4, Case 1 Roentgenogram taken April 20, 1929



Fig 5 Case 2 Shows same conditions and course as Case 1 (Feb 1 1930) (Above)



Fig 7 Case 2 Roentgenogram taken Aug 21, 1930 (Below)



Fig 6 Case 2 Roentgenogram taken May 3, 1930 (Above)

Fig 8, Case 2 Roentgenogram taken Jan 17, 1931 (Below)

from the fibrous tissue and by the surrounding live bone lamellæ, but the blood supply of the region is too inadequate to bring about solid replacement. Eventually, as the child approaches adult life, an equilibrium is reached in which the blood supply is able to take care of whatever is left of the epiphysis. Just how long it takes for the entire involved area to become solid can only be surmised.

We have selected the roentgenograms of two very typical cases of Perthes' disease for use in calling attention to the closeness with which the roentgen course follows the pathologic descriptions.

In the earlier films appears the massive subchondral bone necrosis, manifested by the increased sequestrum-like density of the areas of bone in the femoral heads. At this time, and throughout the course of the disease, the intact condition of the surface cartilages is attested by the absence of any narrowing of the joint space. In these two cases that are being shown, the epiphyseal cartilages are probably involved.

In the later films, the necrotic bone mass (or masses) gradually diminishes in size

through absorption, and becomes surrounded by a clear zone, the zone of granulation tissue and fibrous tissue replacement. In some of the older cases, there is doubtless also osteoid tissue in this surrounding zone. In the final few films of the series, the density of the zones surrounding the necrotic bone is greater than that of fibrous and osteoid tissue, and indicates the presence of repair bone. The flattening and deformity of the heads, with their diminished size, support Zemansky's pathologic observation that the necrosis is far in excess of the reparative processes.

#### SUMMARY

The agreement of roentgen findings with pathologic findings in Perthes' disease is discussed.

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# AN X-RAY STUDY OF THE POST-OPERATIVE STOMACH<sup>1</sup>

By JOHN R. CARTY, M.D., SYDNEY WEINTRAUB, M.D., and ROBERT K. FELTER, M.D., *New York Hospital, New York City*

THE following paper is an analysis of 144 cases of peptic ulcer which have received surgical treatment. This material represents the work of many different surgeons employing various techniques and, we believe, presents a fair cross-section of gastric surgery for this condition. Each patient was interviewed personally,

their symptoms and ability to continue with their routine of life. We will endeavor to show that the x-ray examination of the post-operative stomach is of importance for the following reasons:

1 That there is a definite correlation between the radiographic findings and the clinical results



Fig 1 (A 65346) (1) Pre-operative, post-pyloric ulcer, with obstruction (B) Ten months after posterior gastro-enterostomy. Good clinical and radiographic result. Stomach has diminished considerably in size occupying a higher and more lateral position.

a careful history was taken, and a physical examination was made. In the beginning of this study each patient received a fluoroscopic examination only, but as the importance of the work became apparent, each was also plated. Most of these patients have been seen both before and after operation, and many of them have been under observation for as long as ten years. The clinical results have been judged by the patients' statements as to

<sup>1</sup> Read before the Radiological Society of North America at Atlantic City, Nov. 25-Dec. 1, 1932.

2 That, by means of an x-ray study, one can prognosticate a good or a poor clinical result.

3 That the radiologist can be of assistance to the surgeon in pointing out the causes for some of the poor results obtained in gastric surgery.

Although the appearance of the post-operative stomach varies according to the type of operative procedure employed, nevertheless, there are certain striking characteristics common to all that are functioning well and producing no symp-



Fig 2 (A 32,266) (A) Pre-operative, post pyloric ulcer (B) Two months after posterior gastro-enterostomy Stomach has not diminished very much in size (C) Eight months post-operative, stomach increasing in size and losing its tone Patient has had return of symptoms

toms In the first place, it is a much smaller stomach and occupies a higher and more lateral position Secondly, the peristaltic activity is diminished and there is a lessening of mobility Finally, the emptying of the stomach is much more rapid In the types of operations depending on a new opening in the stomach, that is, the gastro-enterostomies and various types of resection, the stoma should be so placed that free drainage is maintained In our series of posterior gastro-enterostomies, the stomata which were placed near the pylorus gave the best clinical results The size of the stoma is also important, the larger the stoma the better the drainage Rapid emptying of the post-operative stomach appears to be desirable and in not one of our cases did this produce untoward symptoms such as diarrhea

Deviations from the above criteria are apt to coincide with poor clinical results, the most important of these being the size of the post-operative stomach If there has not been a considerable diminution in size, it is a sign of poor drainage and the patient is more apt to have a poor clinical result Poor drainage is due to the following causes (1) the stoma being too small, (2) poor placement of the stoma,

(3) the proximal loop of the anastomosis is too long, (4) a kinking of the distal loop at the mesocolon It was found that if any of the above factors existed, the stomach not only failed to diminish in size but in many cases actually increased in size In the dilated, obstructed stomach the stoma should be placed near to the pylorus and made especially large because, when the stomach shrinks, the stoma will diminish in size and will be drawn upward and to the left We have all seen the stoma placed at the fundus of the stomach and probably have wondered what the operator had in mind! Another error is the allowance of a too long proximal loop, which will hinder drainage and may establish a vicious cycle It is interesting to note that in the cases in which severe hemorrhage occurred a considerable time after operation, there being no signs or symptoms of a recurrent ulcer, we found that either the stoma was too small or that there was obstruction to the distal loop A possible explanation, which we venture to give, is the formation of varices at the stoma, due to narrowing of the stoma itself or to adhesions which produce obstruction to drainage Some surgeons have a predilection for placing the stoma about two

inches proximal to the pylorus, a type of operation in which the opening behaves like a new pylorus, so that the stomach

tion in size. The clinical results have been found to be good in this type of procedure.

As has been stated previously, the peris-

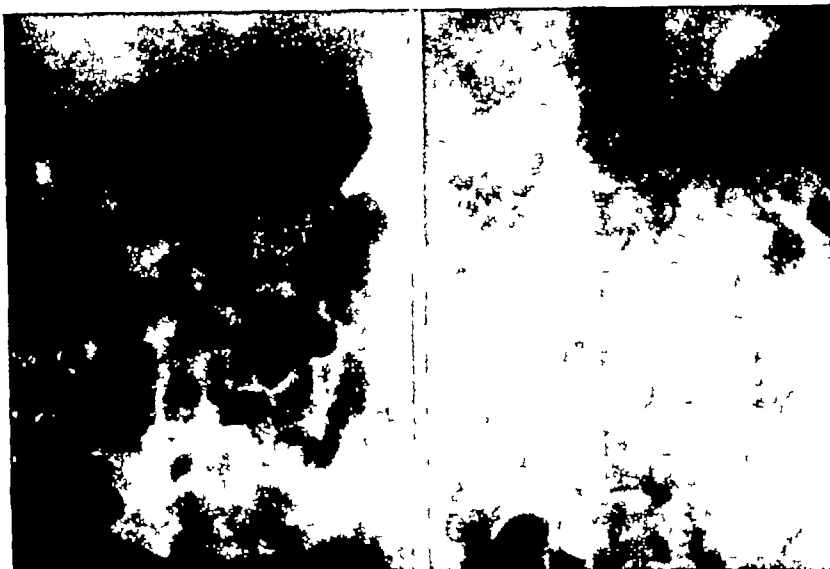


Fig 3 (1,419) (4) Posterior gastro enterostomy for post-pyloric ulcer two years after operation. Patient had developed a severe gastric hemorrhage. Note large active stomach (A) Showing a 9-hour gastric retention. Note narrowing of stoma resulting in poor drainage.

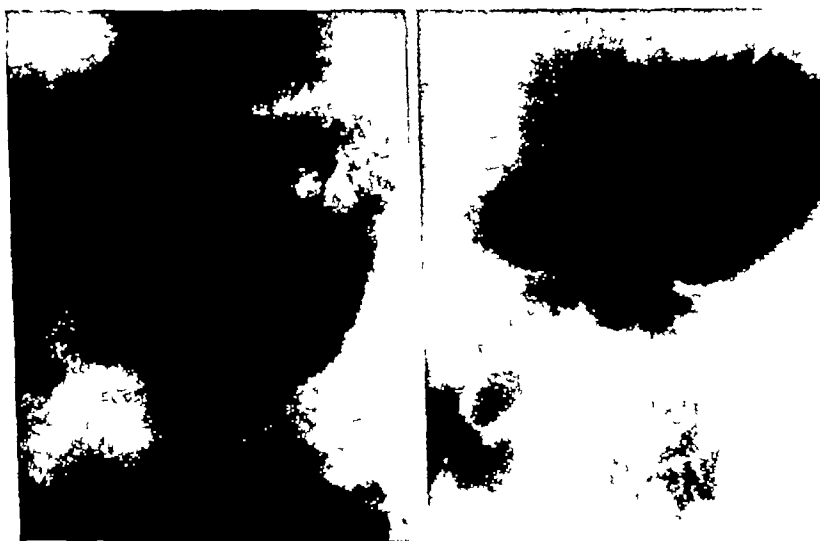


Fig 4 (A 37 600) (4) Before operation post-pyloric ulcer and diverticulum of the second portion of duodenum (B) Two years after posterior gastro-enterostomy. Note increase in size of stomach due to too long a proximal loop. Patient has no clinical symptoms.

does not empty so rapidly and there is, in consequence, not so marked a diminu-

tals of the normal post-operative stomach is considerably diminished. An in-

crease in peristalsis may be the first indication of difficulty and usually precedes the increase in the size of the stomach. Be-

lieve, the pylorus, and may be the cause for the reactivation of an apparently healed duodenal lesion.

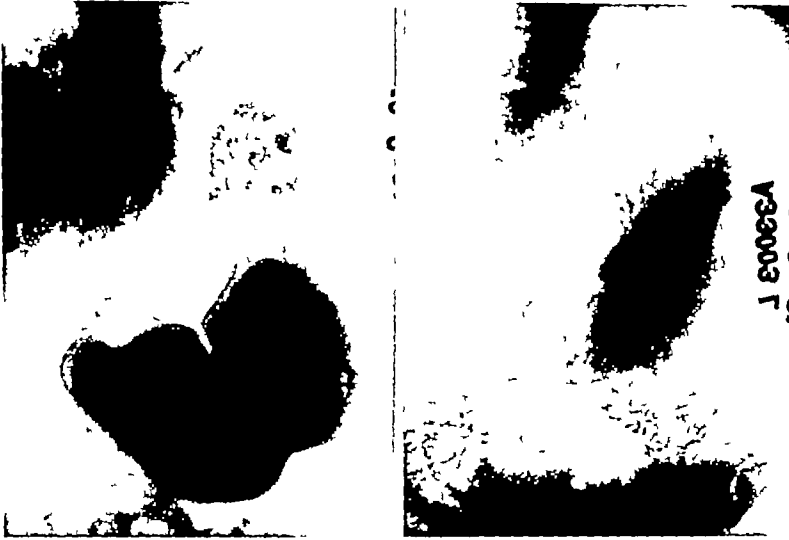


Fig 5 (A 33,093) (1) Before operation, pyloric ulcer, with obstruction (B) Three years after Billroth II resection. Good clinical and radiographic result, good drainage maintained. Note diminution in the size of the stomach.

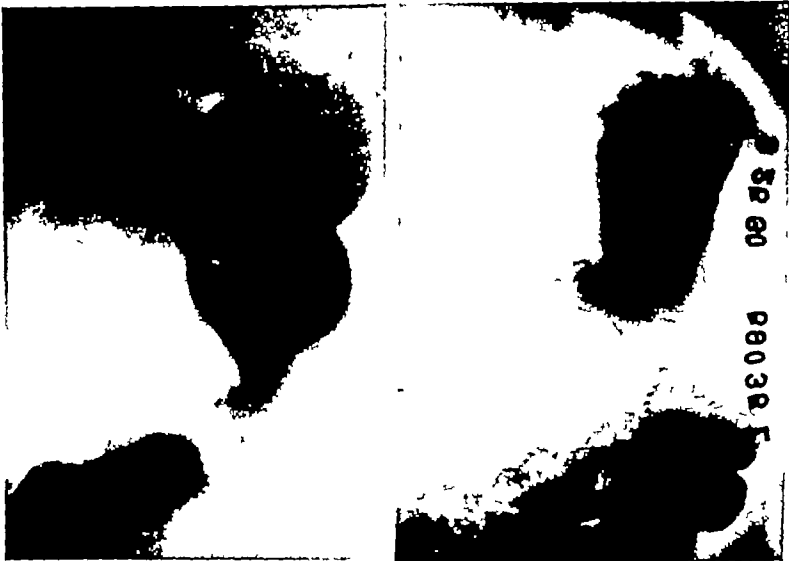


Fig 6 (21,708) (4) Billroth II resection for pyloric ulcer. Note marginal ulcer, increase in tonus and activity of stomach, also spasm of distal loop.

Fig 7 (59,035) (4) Polya resection for pyloric ulcer, good clinical and radiographic result. Note size and shape of stomach, good drainage established.

sides, the increase in activity forces the stomach contents through the old route,

Without knowing the identity of the patients, radiographs of 96 were studied

- 79 were posterior gastro-enterostomies for duodenal or pyloric ulcers  
 1 was for gastric ulcer  
 9 Polya resections for gastric ulcer  
 4 Billroth II resections for gastric ulcer  
 2 pyloroplasties for duodenal ulcer  
 1 anterior gastro-enterostomy for marginal ulcer

From the roentgenologic point of view, the cases were divided into two groups, (a) good results, and (b) poor results. In 84 per cent of the cases the x-ray observations corroborated the clinical results. In 16 per cent the x-ray findings suggested a poor result but this was not verified clinically during the time the patient was under observation. It is our impression, however, that a goodly percentage of the latter will eventually develop difficulties.

The poor results from a radiographic point of view fell into two groups:

1. Those with a disturbance of the mechanical factors, *i.e.*, too large a stomach, poor emptying, over-activity, or poor placement of the stoma. In this group there were 26 posterior gastro-enterostomies, two Polya resections, one Billroth II resection, and one pyloroplasty. There was also one case in which both an excision of a gastric ulcer and a pyloroplasty for duodenal ulcer were done, which illustrated the shortening of the lesser curvature following excision. We also felt that a posterior gastro-enterostomy would have been a better surgical procedure in this case. It is this group, in which poor mechanical results have been found, that we wish particularly to emphasize, because it is here that the roentgenologist can point out not only the causes for the poor result but often predict it. He can also be a factor in reducing the number of poor post-operative results by pointing out to the surgeon the importance of the mechanical factors in gastric surgery.

2. Into the second group of poor results fall the unfortunate cases which have developed marginal ulcers, formed new ulcers at different sites, reactivated the original ulcers, or developed severe gastric hemorrhages. There were 13 posterior gastro-enterostomies and one resection in



Fig 8 (29,570) (A) Polya resection for pyloric ulcer, poor clinical result. Note that stomach is too large, drainage is poor because of too long a proximal loop.

this group. These cases are also often associated with poor mechanical function. Although we cannot presume to say that poor mechanical function is a cause for the formation of new ulcers, nevertheless we feel that at times it possibly is an important factor. We have also noted a peculiar spasm of the proximal loop in marginal ulcers which impedes the emptying of the stomach. This sign may have some diagnostic significance.

The x-ray technique employed in the examination of the stomach has often been discussed. It will suffice to say it is essential that the examiner be aware of the fact that the patient has had an operation before beginning his examination. It is important to follow the first swallow of barium in order to obtain a good conception of the channels through which it passes. Marginal ulcers are identified by a constant fleck of barium at or near the site of the stoma. Tenderness of this



fleck is usually present. These ulcers may be overlooked if the stomach is too full of barium, and at times can be demon-

strated only during the fluoroscopic examination as to prognosis, and finally, that it can aid surgery in reducing its number of serious complications

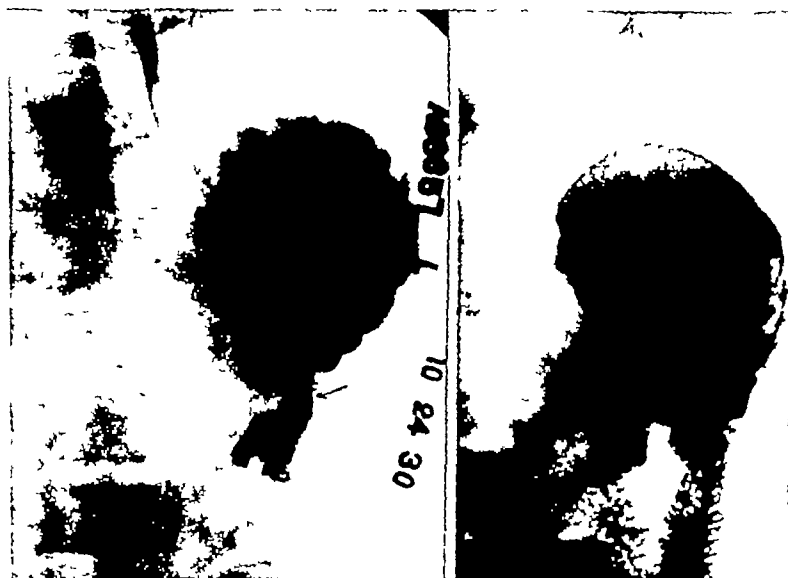



Fig 9 (A 6805) (A) Posterior gastro-enterostomy for post pyloric ulcer. Recurrent ulcer in distal loop. Note spasm of jejunum. (B) Second operation: resection of recurrent ulcer—anterior gastro enterostomy. Good clinical result three years after second operation.

In conclusion, we wish to emphasize

that an x-ray examination of the post-operative stomach is a vital part of a follow-up study, that it gives valuable informa-

# SOME PROBLEMS AND RESULTS IN CHOLECYSTOGRAPHY<sup>1</sup>

By CASSIE B. ROSE, M.D., *Presbyterian Hospital, Chicago*

 CLINICIANS often inquire of the roentgenologist as to the dependability of cholecystography in the diagnosis, and differential diagnosis, of gall-bladder disease, and if it is preferable to give the dye orally or intravenously.

The data of 20 American authors who report statistics concerning their series of cholecystographies, particularly those checked by surgery, are presented in this paper, in addition to the data which I obtained from a study of cholecystographies done in the Presbyterian Hospital, Chicago.

These 20 authors reported a total of 39,280 cases, of which 5,983 came to operation. The figures are incomplete as to the method of giving the dye. From statements in their writings, however, I judge that most of Kirklin's patients were given dye orally, and most of Moore's, intravenously. These are the two largest groups of this series. Others report the dye given 6,729 times orally, and 2,431 times intravenously. It is probable that the dye was given more often orally.

The figures are complete as to the number coming to operation, with the percentage of cases in which the x-ray diagnosis of a pathologic gall bladder was confirmed. The figures are incomplete as to the number of cholecystograms from which diagnoses of normal or pathologic were made. As far as is given, 4,705 were called normal, and 4,813 pathologic.

The largest number of cases is from the Mayo Clinic, in which 3,517 were operated on out of a total of 25,191. Kirklin divides the cases into four groups with respect to the reliability of the x-ray diagnosis:

- 1 Non-functioning gall bladder, with and without stones, 95 per cent

- 2 Poorly functioning gall bladder, with and without stones, 94 per cent
- 3 Normally functioning gall bladder, with stones, 100 per cent
- 4 Normally functioning gall bladder, without stones, 81.5 per cent

Averaging the first three figures of his conclusions, we may say that in 96 per cent of the cases the x-ray diagnosis of a pathologic gall bladder was confirmed by operation, an error of only 4 per cent, while the x-ray diagnosis of normal was found to be erroneous in 18.5 per cent.

Similar figures are given by the other authors in confirmation of the x-ray report of pathology. Their percentages range from 86.4 to 100. The average is 93.3 per cent.

Only seven of these 20 authors give the percentage of cases in which the x-ray diagnosis of normal was confirmed surgically. These are Lord, 52.6, King and Martin, 55, Watkins and Mills, 68.2, Kirklin, 81.5, Case, 83.4, Aspray, 93.7, and Beilin and Carlson, 100 per cent. The average of these figures is 76.34 per cent.

Recently I reviewed the records of 1,616 patients of whom cholecystograms, following essentially the Graham-Cole technic, had been done. In our hospital, the dye is given orally or intravenously, according to the desire and judgment of the attending physician, who also administers it.

The patient is given a light evening meal at about 6:00 P.M., and the dye is given about 9:00 P.M. Food is then withheld, although water may be taken, and the patient is sent to the roentgen department at 9 the next morning. Routinely, films are taken at 9 and 12 o'clock, to show the gall bladder filling, then a meal of high fat content is given and a film made at 2 o'clock, to determine the emptying of the gall bladder.

<sup>1</sup>Read before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 25-Dec. 1, 1932.

Variations in this routine are as follows. If the gall bladder is slow in filling, the fat meal is withheld until after the 2 o'clock film, and a 4 o'clock film is made to determine the emptying. If the gall bladder filled well, but emptied poorly at 2 o'clock, a film is taken at 4 o'clock to determine delayed emptying. In addition, if the gall bladder is obscured by gas or fecal material, the patient is given one or more enemas during the course of the examination, in an attempt to clear the bowel and secure a better visualization of the gall bladder.

Wet films are examined in order to make any needed change in the routine and to secure the best work in each case by the roentgen department. It is very important to get films of good technical quality which are free from movement. When the gall-bladder examination is complete and the films are dry, the final report is made.

I have already discussed the interpretation of films and will not repeat the matter here (21).

In the series of 1,616 cases reviewed for this report, 1,712 cholecystograms were made, due to re-checks. In 868 of these, or 50.7 per cent, the dye was given orally, and in 844, or 49.3 per cent, the dye was given intravenously. The x-ray findings were reported as normal in 911 examinations, and as pathologic in 801. The x-ray reports were considered to check with clinical findings in 1,386 cases in which 686 intravenous and 700 oral administrations were made, they did not check in 326 cases, 155 intravenous and 171 oral administrations of the dye.

Of these patients 295 were operated upon. In 209, there was a pathologic gall bladder with stones, in 53, a pathologic gall bladder without stones, and in 33, the gall bladder was normal. The x-ray diagnosis failed to check with the surgical diagnosis in only 25 out of the 286 cholecystograms done on the pathologic groups. These 25 cases, 14 oral and 11 intravenous administrations of dye, had been reported on roentgenographically as normal in function. Two gall bladders, although

normal in function, were reported to contain stones which were not found at operation.

In the 33 cases in which a normal gall bladder was found at operation, there were 34 cholecystograms, 28 of which checked, six did not check with the operative findings, two oral and four intravenous administrations of dye.

The x-ray diagnosis of a normal gall bladder checked with the surgical findings in 64.7 per cent of the cases, the x-ray diagnosis of a pathologic gall bladder was checked surgically in 96.76 per cent. The x-ray and clinical diagnoses checked in 81.8 per cent.

The greatest number of errors was in diagnosing as normal those cases which, at operation, showed chronic cholecystitis without stones. Several of these cases were reported as "slight chronic cholecystitis." It is well known that a moderate degree of chronic gall-bladder infection need not seriously impair the function of that organ.

Other mistakes in this series operated upon were caused by gas in the bowel. Once a normal gall bladder appeared to fill faintly, twice stones were reported which were not present at operation, and twice stones found by the surgeon had been interpreted roentgenographically as gas in the bowel. On one of these, the report was, "Normally functioning cholecystogram with several gas bubbles partly overlying the gall bladder. Adjacent to them is a smaller round area of decreased density which remains within the gall-bladder outline on all three films. Probably gas, but cannot rule out stone." This shadow shifted position somewhat within the gall bladder. While operating upon this patient for a duodenal ulcer, the surgeon palpated a pea-sized stone in the gall bladder. On reviewing the films, I believe I should have had more courage and reported this shadow as a positive stone. Still it illustrates a common source of difficulty in diagnosis.

In nine cases, carcinoma was found at operation: four times in the head of the pancreas, twice in the gall bladder, once

each in the ampulla of Vater, the stomach, and an ovary. Three of these had metastases to the liver. In the case of carcinoma of the stomach with liver metastases, and in one case of carcinoma of the head of the pancreas, the gall bladder was normal surgically and roentgenographically. In the other seven cases, there was a non-functioning gall bladder roentgenographically, which could be accounted for at operation by disease of the gall bladder itself, by compression of its duct, or by extensive liver metastases.

Liver dysfunction was reflected cholecystographically in the case of a male patient, age 23 years, who was suffering from an acute catarrhal jaundice. Three cholecystograms were made, with oral administration of the dye, the second being made after two days, the third, after six days. Upon evidence of the first two, the gall bladder was reported as non-functioning, after the third it was reported to be normal. The jaundice had markedly subsided three days before the last cholecystogram.

Cysts of the gall bladder were found twice at operation. In one case, the intravenous cholecystogram showed a "very faint filling," which was explained surgically by a cyst, 1 cm in diameter, near the gall-bladder neck, which apparently had caused a partial compression. In the other case, a soft round shadow on the plain film corresponded with the position of the round gall-bladder outline seen on the cholecystogram made when the contrast medium was given intravenously. There was fairly normal gall-bladder function. It was also noted that the partly emptied gall bladder was smaller than the soft shadow on the plain film. These findings were explained later when a cyst was found in the lower pole of the gall bladder, lined with the same type of mucous membrane as the rest of the gall bladder and connected with it by a small opening the size of a pea. Evidently this cyst had been visualized faintly on the plain film, and had filled and partly emptied during the making of the cholecystogram.

Of interest, because of his youth, is the case of a boy 18 years old, in whom a cholecystogram showed a poorly filled gall bladder with stones. This diagnosis was confirmed surgically a year later.

It is not surprising that duct stones are rarely, if ever, demonstrated as such roentgenographically, or that they either partly or completely prevent the filling of the gall bladder. Two such cases in this series illustrate the value of a close co-operation between the roentgenologist, the clinician, and the surgeon. In both these cases the gall bladder, at operation, seemed normal, and no stones could be palpated in the gall bladder or the ducts. And yet, because the clinician stated that the symptoms were those of an obstructed gall bladder, and because the roentgenologist had reported "no filling," the surgeon probed the duct and found, in each case, a small stone.

In another patient, a man of 60 years, the gall bladder was seen to be non-functioning upon administration of dye intravenously. At operation, the gall bladder was found to be of normal size, it was thick and contained several stones. It lay in a dense mass of adhesions, and, as the patient was fat, the duct was difficult to palpate. Because of the patient's condition, it was deemed unwise to attempt further exploration, although, from the symptoms, a duct stone was suspected. A few days later, at the post-mortem examination, it was found that the common bile duct was dilated to 2.5 cm in diameter, and obstructed by a stone in the ampulla.

The following case illustrates how persistently a gall bladder may sometimes retain its normal function, even after recurrent stones and a considerable amount of surgery.

On Sept. 28, 1928, this woman's gall bladder was found in a mass of adhesions. It was very difficult to dissect out and was so adherent to the pancreas that it could not be removed. The atrophied gall bladder was drained and found to contain two large and several small stones. The

TABLE I

Author	Number of Cases	Method of Administration	Cholecystography		Surgical Check		
			Normal	Pathologic	Number Operated On	Normals Checked Correctly	Pathology Checked Correctly
Carman and Counseller (1)	178	Intravenous			39		87 per cent
Zink (2)	663	Oral and Intravenous			131		94.2 per cent
Stewart and Ryan (3)	100	Oral	40	60	23		95 per cent
Whitaker (4)	60	Intravenous			28		93 per cent
King and Martin (5)	407	Oral			62	55 per cent	88 per cent
Chandler and Newell (6)	662	Oral and Intravenous			50		
Aspray (7)	498	Oral and Intravenous	186	312	80	93.7 per cent	100 per cent
Stewart and Illick (8)	600	Oral	273	327	69		97.1 per cent
Oakman (9)	305	Oral	143	162	37		97.3 per cent
Lord (10)	100	Oral and Intravenous	19	81	100	52.6 per cent	86.4 per cent
Lockwood and Skinner (11)	1,500	Oral	890	610	192		96.4 per cent
Watkins and Mills (12)	625	Oral	305	320	100	68.2 per cent	97 per cent
Case (13)	2,000	Intravenous			277	83.4 per cent	90 per cent
Robins and Goldberg (14)	1,014	Oral	502	512	182		85.5 to 87 per cent
Kirklin (15)	25,191	Oral and Intravenous			3,517	81.5 per cent	96 per cent (average)
Moore (16)	3,044	Oral and Intravenous	1,477	1,567	416		98.7 per cent
Hawley (17)	500	Oral and Intravenous	236	242 (22 in conclusive)	146		90 per cent (oral) 91 per cent (intravenous)
Beilin and Carlson (18)	750	Oral			150	100 per cent	98.3 per cent
Fleming (19)	233	Oral and Intravenous			233		88.2 per cent
Littig and Lisk (20)	800	Intravenous	403	397	151		
Rose (21)	1,616	Oral and Intravenous	911	801	295	64.7 per cent	96.7 per cent

ducts could not be palpated, although the symptoms indicated that a common duct stone was present.

On Dec 10, 1928, the patient was operated upon again. There were adhesions which were easily broken up. The gall bladder was shrunken, and no stones could be palpated in it, or in the cystic duct. A stone the size of a pea could be felt in the common duct, at the ampulla of Vater, but it could not be forced back. The ampulla was then enlarged, and the stone removed from the duct.

On June 24, 1929, an intravenous cholecystogram showed normal function, with two large negative or cholesterol stone shadows within the gall bladder.

On July 24, this patient was operated

upon for the third time within 10 months. On exploring, stones could be seen through the gall-bladder wall. At this operation it was possible to free the gall bladder from the liver down to the cystic duct, and to remove it.

The following case history is of interest from the standpoint of the diagnosis of stones by x-ray. It also indicates something of the rapidity of their growth, and how difficult it may be to palpate them at operation.

The clinical history of a woman who was studied in our hospital in May, 1925, suggested gall bladder disease. On the plain films there were four small, round areas of decreased density which were considered to indicate small gallstones. (This was before we had begun to use

cholecystography) In October, the clinical story was even more suggestive of gallstones We were then using cholecystography and we, therefore, studied the patient after both oral and intravenous administration of the dye Roentgenograms showed a normally functioning gall bladder which contained four small, round areas of decreased density, each 4 mm in diameter Since these were repeated on all films, the diagnosis was certain The patient returned home and was operated upon there by the surgeon of her choice, a man of good reputation He stated that the gall bladder felt entirely normal, and that he could not feel any evidence of stones He did not open it While in the hospital, the patient had an attack similar to those noted in the clinical history, though more severe than any previous one Other lesser attacks followed at infrequent intervals

In April, 1927, this patient returned to us and the cholecystogram was repeated The films taken two years after our first study, demonstrated four round areas of decreased density, 1 cm in diameter, in the dye-filled gall bladder, showing that in the two years the stones had grown to about four times their previous size She was operated upon within a few days and the gall bladder, containing four stones, was removed

#### CONCLUSION

The accuracy of the x-ray diagnosis is slightly better with intravenous than with oral administration of dye In my opinion, however, this difference is so small that it is entirely fair to give the dye by the oral method first, since it is a more simple procedure and less apt to cause a reaction, including a sore arm If oral administration is not satisfactory, recheck with the intravenous method

The x-ray diagnosis of a pathologic gall bladder is dependable up to about 98 per cent On the other hand, the diagnosis of a normal gall bladder by the x-ray is correct in an average of only 76 per cent of cases although we have one report of 100 per cent It is in this "x-ray normal"

group that the co-operation between the clinician or surgeon and the roentgenologist is most important

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# PNEUMONOCOCONIOSIS

WITH SPECIAL REFERENCE TO SOME OF ITS COMPLICATIONS<sup>1</sup>

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**P**NEMONOCOCONIOSIS is a lung disease due to inhalation of minute particles and characterized pathologically by fibroid induration and pigmentation. Although it has been known for many years (Ramazzini, 1703) that dust inhalation incident to certain occupations and trades is accompanied by varying forms of pulmonary fibrosis, still it is only within the last half-century or over, with its enormous industrial development, that pneumonococoniosis has assumed importance as a disabling disease. The different types of pneumonococoniosis vary in relation to the industry; thus, we meet with anthracosis in coal miners, silicosis in rock drillers, asbestosis in asbestos workers, siderosis in gold miners, byssinosis in cotton mill workers, etc. In each of the industries mentioned, these factors, in the order of increasing importance, tend to cause the development of pulmonary fibrosis (pneumonococoniosis).

(1) *Shape*—The sharp angular particles exert an irritative action on the lungs and are more dangerous potentially, although this is disputed by some authorities.

(2) *Size*—Small particles below 10 microns, other things being equal, are more hazardous.

(3) *Extent of Exposure*—The time element requisite for the development of pneumonococoniosis in the dusty trades varies in different industries, in some as low as two years or even less.

(4) *Number of Dust Particles per Cubic Foot of Air*—It has been estimated that if the number exceeds ten or fifteen millions, the development of pneumonococoniosis is likely, if twenty millions or over,

it is almost certain, unless preventive measures are adopted.

(5) *Physio-chemical Properties*—(A) organic dusts, (B) inorganic dusts. (A) Some authorities are of the opinion that they play no part in the production of pneumonococoniosis, yet pulmonary fibrosis as a result of cotton-mill-dust inhalation is a recognized form of pneumonococoniosis. It is held by most writers that this is due to the admixture of inorganic particles with the organic dust. (B) These differ in their potency, as, for example, coal and lime (15) are relatively benign, while silica dust is regarded as the most dangerous. Indeed, the view is held that in all dust inhalation the silica content is the main fibrosing agent.

Heffernan (7) is of the opinion that when the silica dust is deposited in the alveoli of the lungs, it is acted upon by the alkaline fluids and transformed into colloidal silica, which exerts a deleterious action on the pulmonary tissue. He further believes that the pulmonary fibrosis encountered in asbestos workers is due to a transformation of the silicates in asbestos into colloidal silica.

Silicosis according to this hypothesis results from the action of colloidal silica on the pulmonary tissue, and the acuteness or chronicity of the process depends largely upon the silica concentration and the rapidity with which it is transformed into silica sol. Chapman (3) reports three cases of acute silicosis, with autopsy findings in two of them, as a result of comparatively short exposure (about two years) to an alkaline silica mixture in the manufacture of scouring soaps.

As to the mechanism of the process involved in the production of pulmonary fibrosis, the protection offered by the cilia of the upper respiratory tract is broken down under the continuous and

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prolonged inhalation of massive dust doses, so that the dust particles gain entry into the alveoli. The mononuclear phagocytes which are derived from the alveolar walls, and which form the second line of defense (10), endeavor to engulf and destroy the foreign particles the débris of which is drained off through the lymphatics. Under unfavorable circumstances the phagocytes themselves may undergo destruction, the lymphatic structures and subpleural spaces may become clogged with the foreign particles, an attempt at encapsulation may be made by the fibroblasts, and fibrosis initiated. The amount of hyperplasia and induration resulting varies with the character and quantity of dust deposited in the lung tissue and the length of exposure. Gardner (5), in autopsy reports on silicotics, finds that "The tracheobronchial lymph nodes present even more extensive lesions than are found in the lung. The sinuses are in most places obliterated by reaction to excessive amounts of dust or by healed and calcified tubercles. In other places they are greatly dilated. Around the node is dense fibrous tissue which has caused a dilatation of the afferent lymph vessels." He advances the interesting hypothesis that the primary lesion of silicosis is located in the tracheobronchial lymph nodes and that their partial obstruction by healed foci of infantile tuberculosis has a determining influence on the rapidity with which workmen develop silicosis. Thus, if a workman presents such healed foci, he will develop sufficient connective tissue in a relatively short time to complete the obstruction to the lymph flow and hence the dust, finding no other egress, will accumulate within the lung.

The symptoms and physical signs displayed will vary with the amount of pulmonary fibrosis. On clinical grounds three stages may be described—mild, moderate, and advanced. In the first stage, few or no physical signs are obtained on physical examination. Roentgenologically, however, there is a definite increase in the hilum and trunk shadows

and linear markings, the diaphragm (right leaf) may show a slight ascent due to an accompanying pleuritis. The roentgen appearance in this stage may be confused with that of cardiac decompensation, bronchitis (acute or chronic), and asthma, hence the importance of the occupational or medical history. In the second stage there is a history of cough with little or no expectoration, of chest pains, and the following physical signs: dyspnea on exertion, deficient lung expansion, impaired resonance on percussion, diminished breath sounds, with occasional dry râles and friction rubs at the lower bases. The x-ray reveals more or less diffuse mottling through the lung parenchyma owing to deposition of the dust in the lymph spaces. This mottling is usually more prominent at the bases than at the apices and initially more marked on the right side. In the third stage, clinically, there is an accentuation of the signs and symptoms encountered in the second, *viz*, chest pains, deficient lung expansion. Dyspnea is a prominent symptom in some cases, especially of asbestosis, in which marked loss of weight and facial pallor are noted. Roentgenologically, there is a coalescence of the nodular areas noted in the second stage into opaque shadows simulating consolidations. Cases of asbestosis differ radiologically in the second and third stages in that the fibrosis appears softer and more delicate, the indurative changes being more interstitial. Pulmonary tuberculosis in the second and third stages, especially that of silicosis, is not an infrequent complication.

#### CASE REPORTS

We present six cases illustrative of different types of pneumoconiosis in various stages.

Case 1 J C D, white male, 39 years of age, married, coal miner for past 13 years, was admitted to the Veterans' Administration Hospital, Memphis, Tenn. on Jan. 11, 1932, for treatment of valvular heart disease with cardiac hypertrophy,





Fig 1 Shows marked increase in hilum and trunk shadows, with scattered fine mottling in both lungs  
*Diagnosis* Anthracosis, late first stage or early second (coal miner for 13 years)

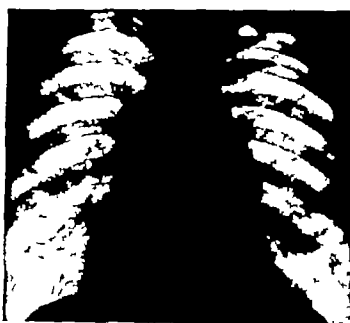


Fig 2 Shows increase in hilum and trunk shadows, with accentuation of linear markings and fine nodular mottling in both lungs  
*Diagnosis* Pneumonoconiosis byssinosis (Patient had been a textile worker for past 12 years)



Fig 3 Shows diffuse mottling especially in upper lobes. This nodular mottling appears soft and shows a tendency to conglomeration, costophrenic angles partially obliterated  
*Diagnosis* Silicoanthracosis, late second stage, or early third (Coal miner for 30 years, sputum persistently negative for tubercle bacilli guinea pig negative)

chronic tonsillitis, and sinusitis. Complaints on admission were shortness of breath and joint pains. Family history was negative. The man gave a personal history of the ordinary diseases of childhood, typhoid fever (1910), malaria, pleurisy (1911). *Physical examination* Ears, eyes, nose, and throat were negative except for infected tonsils, which were subsequently removed. *Chest* Expansion good and equal on both sides, few roughened breath sounds (both lungs), with no râles. Temperature, pulse, and respiration, normal. Blood pressure 126/80. Heart examination essentially negative. The remainder of the physical examination was unimportant. *Laboratory reports* Blood count and blood chemistry within normal limits, Wassermann and urinalysis negative. Roentgenogram of chest showed marked increase in hilum and trunk shadows, with scattered fine mottling in both lungs. *Diagnosis* Anthracosis, first stage (late) or early second. (See Fig 1)

Case 2 C J R, white male, age 33, married, occupation textile worker for the past 12 years, was admitted to the Veterans' Administration Hospital, Memphis, Tenn., on April 20, 1931, with complaints referable to the nose and eyes. Family history was negative. *Personal history* Ordinary diseases of childhood, hospital-

ized for sinus infection while overseas, acute bronchitis (1930). *Physical examination* Special ear, eye, nose, and throat examination gave a diagnosis of chronic catarrhal otitis media, bilateral, mild, deviated nasal septum. Examination of the chest was essentially negative, except for slight increase and roughening of breath sounds. Temperature, pulse, and respiration were normal, blood pressure, 110/80. Cardiac and remainder of physical examination negative. *Laboratory tests* Blood count within normal limits, Wassermann and urinalysis negative. Roentgenogram of chest (Fig 2) showed increase in hilum and trunk shadows, with accentuation of linear markings and fine nodular mottling in both lungs. This case is of interest as illustrating another type of pneumonoconiosis, *viz*, byssinosis.

Case 3 S M, white male, age 55, height 5 feet, 8 inches, weight 155 pounds, was admitted to Sea View Hospital, Staten Island, N. Y., complaining of persistent cough, dyspnea on slight exertion, and expectoration. He had been a coal miner for the past thirty years. *Physical examination* Head and neck negative, chest showed decreased expansion, with impaired resonance on per-



Fig 4 Shows diffuse mottling more marked in upper lobes due to coarse dense nodules. Questionable areas of decreased density at upper apices. Pleuritic adhesions at base. *Diagnosis* Silicosis, second stage, complicated by pulmonary tuberculosis. (Occupation, rock driller for past 12 years, sputum positive for tubercle bacilli.)



Fig 5 Shows diffuse mottling from upper apices to lower bases and somewhat more marked on right side. Cavitation in right upper lobe, both costophrenic angles obliterated. *Diagnosis* Silicosis complicated by pulmonary tuberculosis with cavitation. (Occupation, rock driller for past 20 years, sputum positive for tubercle bacilli, frequent hemoptyses one rather severe. Pneumothorax on right side unsuccessful on account of adhesions.) (Above)



Fig 6 Shows marked ascent of both leaflets of the diaphragm with obliteration of right costophrenic angle. Hilar and trunk shadows increased in size and density. Haziness of right upper lobe, ground-glass appearance of film. (Data: 22 sputa examinations negative for tubercle bacilli, yeast, or fungi, guinea pig negative for tuberculosis. (Occupation asbestos worker for 7 years previously mill operator.) (Below)

cussion from upper apices to lower bases. On auscultation the breath sounds were found to be decreased, a few dry râles were elicited in both infraclavicular regions, with occasional friction rubs at the lower bases. The remainder of the physical examination was essentially negative. Temperature, pulse, and respiration were within normal limits. *Laboratory data* Blood, urinalysis and Wassermann tests were negative. The sputum measured about a quarter of a cupful daily, and 20 sputa examinations were negative for tubercle bacilli. Guinea pig injection was negative for tuberculosis, roentgenogram (Fig 3) shows diffuse mottling from the upper apices to the lower bases, more marked at the central and middle zones. This nodular mottling appears soft and shows a tendency to conglomeration. Costophrenic angles are partially obliterated, heart and aorta are normal, hilum and trunk shadows are accentuated. *Diagnosis* Pneumonoconiosis anthracosilicosis, second stage (late) or early third.

In anthracite mining the question of silica as contributing towards pneumono-

coniosis, assumes importance and where the workman has to cut through siliceous layers the subsequent pulmonary changes may be those of silicosis. However, coal dust is in general regarded as deterrent to the development of silicosis. Case 3 may perhaps serve as an illustration of the



Fig 1 Shows marked increase in hilum and trunk shadows, with scattered fine mottling in both lungs  
*Diagnosis* Anthracosis, late first stage, or early second (coal miner for 13 years)

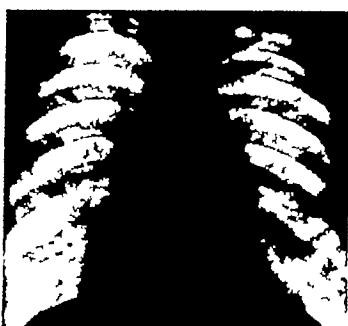


Fig 2 Shows increase in hilum and trunk shadows, with accentuation of linear markings and fine nodular mottling in both lungs  
*Diagnosis* Pneumoconiosis byssinosis (Patient had been a textile worker for past 12 years)



Fig 3 Shows diffuse mottling especially in upper lobes. This nodular mottling appears soft and shows a tendency to conglomeration, costophrenic angles partially obliterated  
*Diagnosis* Silicoanthracosis late second stage, or early third (Coal miner for 30 years, sputum persistently negative for tubercle bacilli, guinea pig negative)

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pation, mill operator, enlisted May 3, 1917, discharged Sept 28, 1922, on sick call many times for shortness of breath, post-war occupation, asbestos-plant operator for the past seven years, admitted to Veterans' Administration Hospital, Memphis, Tenn, Dec 21, 1931. The family history was unimportant, and the personal history included pneumonia at 15 (previously hospitalized elsewhere for chronic bronchitis, pleuritis, pulmonary tuberculosis far advanced, and pneumoconiosis). *Chief complaints on admission* shortness of breath, cough, with some expectoration, loss of weight, easy fatigability, indigestion.

Physical examination disclosed an undernourished white male of asthenic type, 5 feet, 10 inches in height, and weighing 115 pounds. There was marked dyspnea on slight exertion, facial pallor, and mild clubbing of finger nails. Tonsils were embedded and appeared infected, pharynx congested, larynx somewhat reddened, teeth in good condition. Chest was elongated and flattened, with marked decrease in mobility of both lower chest walls, and atrophy of the pectoral muscles, especially on the right side. On palpation there was increased tactile fremitus in the right upper lobe, with diminution at the right and left lower bases. The percussion note was somewhat accentuated in the right infraclavicular region and diminished at the right lower base. The left lung gave impaired resonance from the fourth interspace midaxillary line downward. Auscultation of the right lung revealed whispered fremitus, increased in upper lobe anteriorly and posteriorly, dry râles (which persisted after coughing) in infraclavicular region. The cough was amphoric in character and there was suggestive cavernous breathing in the right infraclavicular space. In the region of the right lower lobe, breath sounds were distinctly diminished. Auscultation of the left lung showed scattered dry râles on coughing, and diminished breath sounds at the lower base. Cardiac sounds were normal. Blood pressure was 115/75, tem-



Fig 7 Film taken after lipiodol injection shows marked deviation of trachea to right and dilated bronchi

perature, 98°, pulse, 84, respirations, 20. Sputum was mucoid in character and averaged from one-half to three-fourths of a cup per day. Cough was persistent, especially during the morning hours when most of the sputum was expectorated. The remainder of the physical examination was negative. *Laboratory data* red blood cells, 4,500,000, white blood cells, 4,600, polymorphonuclears, 54, small mononuclears, 44, eosinophils, 2, hemoglobin, 89 per cent, urinalysis, negative, 22 sputum analyses were negative for tubercle bacilli, yeast, or fungi, injected guinea pig proved negative on autopsy, no asbestosis bodies demonstrated. Electrocardiogram showed normal sinus rhythm with deepening of S in lead one, and left axis deviation, the P-R interval and Q-R-S, normal, auricular and ventricular rate, 74. Gastric analysis and x-ray examination of intestinal tract, negative. The roentgenogram of the chest on admission showed (Fig 6) a marked ascent of both leaflets of the diaphragm, with obliteration of the costophrenic angle on the right side and some thickening of the parietal pleura of the right lower lobe. The hilar and trunk shadows increased in size, the linear markings were accentuated. In the region of the right upper lobe a haziness was noted, with radiating strands in the right

end-result of prolonged exposure to coal dust, which is nearly always pulmonary fibrosis unassociated with tuberculosis. Anthracosis is associated with a high pneumonia rate (63 per cent as contrasted with 35 per cent in cases in which anthracosis is not present, according to White). On the other hand, coal miners in general show a low morbidity from pulmonary tuberculosis, a fact which has been construed as showing that coal dust is chemically antagonistic to the tubercle bacillus, while some think the fibrosis incident to the encapsulation of the coal dust in the lungs is defensive against tuberculosis. In this connection, it is interesting to refer to the experiments of Hennes on the treatment of pulmonary tuberculosis by dust inhalation. Taking the fact that lime or sulphur is rarely associated in industry with pulmonary tuberculosis, he treated tuberculous patients by dust inhalations from four to six times daily for two-minute periods, increasing to six or eight times for from five to eight minutes. He continued the treatment for four months, observed the cases for fifteen months, noting improvement in temperature, sputum, pulse, weight, and roentgen findings. He did not demonstrate silicosis roentgenologically in these cases.

Cases 4 and 5, on account of the essential similarity in symptoms and physical signs as well as roentgen data, and for the sake of brevity, will be considered together.

**Case 4** P. A., white male, age 43 years, height 5 feet, 8 inches, weight 150 pounds, occupation, rock drilling in subway excavation work for the past 12 years. *Complaint on admission* shortness of breath, cough, expectoration, occasionally blood-streaked sputum. Family and past histories were negative. *Physical examination* head and neck were negative. Chest—expansion, deficient, impaired resonance of both upper apices and, to a lesser extent, throughout both lungs, on auscultation, roughened breath sounds, with moist râles, were elicited in both apices and occasional friction rub at lower bases. In the infraclavicular region the

breath sounds were somewhat subdued.

**Case 5** H. J., white male, apparent age 40 years, occupation, rock driller for the past 20 years. *Complaint* shortness of breath, cough, with expectoration, history of hemoptysis. *Chest examination* essentially similar to that of Case 4, except that in the right upper lobe there was bronchial breathing with amphoric cough. As shown by Figures 4 and 5, there is a diffuse mottling of the lungs from upper apices to lower bases due to coarse nodules which appear dense and opaque. There is some evidence of pleuritis at the lower bases of both chests, areas of decreased density are noted at the upper apices in Figure 4, and in Figure 5 there is distinct evidence of cavitation of the right upper. *Clinical course* both patients showed a tendency to evening rise in temperature, sputum frequently blood-streaked and positive for tubercle bacilli. Case 5 had several hemoptyses, one rather severe, which led us to attempt pneumothorax on the right side, an attempt which was, however, unsuccessful on account of adhesions. The coincident tuberculous changes in these two cases of silicosis are in keeping with the high incidence of pulmonary tuberculosis as a complication in silicosis. A. R. Smith, in a study made of 208 rock drillers, blasters, and excavators in New York City, found 57 per cent to be affected with silicosis and 9 per cent of the cases to be complicated by pulmonary tuberculosis. The late G. M. Kober, in an analysis entitled "Occupation in Relation to Tuberculosis," showed that the proportional death rate from tuberculosis among bluestone dressers (who are constantly exposed to silica dust in the course of their work) is 77.8 per cent as against 5.6 per cent among lumbermen, who presumably have no exposure to dust containing silica.

The next case to be reported is another form of pneumoconiosis, namely, asbestosis.

**Case 6** R. C., white male, aged 42 years, married, and the father of five children living and well. Pre-war occu-

home, for which reason the examination, perforce, was incomplete. However, there was found tachycardia and generalized tenderness throughout the abdomen, a blood pressure of 118/80, cardiac sounds normal, pulse rate, standing, 122, temperature, 98°, respiration, 20, Wassermann negative, red blood cells, 4,350,000, hemoglobin, 86 per cent, white blood cells, 7,100, polymorphonuclears, 67, small mononuclears, 30, large mononuclears, 2, urinalysis, negative. The patient was readmitted on July 14, 1932, appearing acutely ill, at which time examination showed the following: complexion sallow, apparently jaundiced, right chest bulged somewhat, with marked tenderness at the lower base and dullness from the third rib downward, tenderness and slight rigidity of the upper right abdomen, breath sounds absent on the right side from the third rib downward, exaggerated at the right upper apex, and roughened throughout the left lung, no râles or friction rubs on deep inspiration or coughing, blood pressure, 100/60, pulse rate (sitting), 130, cardiac sounds differentiated—no murmurs elicited, temperature, 99° to 101°, respiration, 20 to 26. The laboratory data were as follows: red blood cells, 3,830,000, hemoglobin, 63 per cent, white blood cells, 6,000, polymorphonuclears, 68, small mononuclears, 26, large mononuclears, 4, eosinophils, 2, urinalysis, negative, Wassermann, negative. *Gastric analysis*: total acidity, 53, free hydrochloric acid, 44. On cholecystography, no outline of the gall bladder was obtained. There was an icteric index of 19.8. The gastro-intestinal series was negative. Twenty consecutive sputum tests were negative for tubercle bacilli. For the x-ray findings of the chest on admission, see Figure 9 and its accompanying legend. We aspirated the right pleural cavity (July 22, 1932), and removed 30 c c of straw-colored fluid for bacteriologic examination. On further aspiration, five days later, 90 c c of straw-colored fluid was removed, the manometric reading being minus one-half, minus two, 50 c c of air given, final read-



Fig 9 Shows an opaque shadow of the right lung which extends from the infra-clavicular region downward obliterating lung parenchyma markings and merges inferiorly with right leaf of diaphragm, and medially with the right cardiac border. In the right upper apex mottling is noted. The left lung is mottled throughout by discrete opaque shadows somewhat suggestive of miliary nodulation. The left dome of the diaphragm is well outlined.

ing, minus one-half, plus three. Pleural fluid was negative for tubercle bacilli or other organisms. A guinea pig inoculated with the pleural fluid was negative on autopsy (Sept 13, 1932). Figure 10, made after aspiration and partial gas replacement, shows no change as compared with the admission film except that several fluid levels are noted at the right lower base, suggestive of encysted effusion. Temperature, pulse, and respiration showed a tendency to subside to normal, the appetite was good, the general condition improved, and subsequent chest films showed no change. The patient left the hospital against medical advice on Aug 17, 1932. A definite pulmonary diagnosis in this case is rather difficult, but it is, most probably, silicosis complicated by encysted effusion on the right side, plus cholecystitis and secondary anemia.

While repeated sputum examinations, as well as guinea pig inoculation, are essential, these, as shown above, may be negative, and a diagnosis can be arrived at only by careful consideration of the complete clinical picture. In cases of asbestosis, the



Fig 8 Oblique position—delineates thickening of parietal pleura of right lung and dilated bronchi  
*Diagnosis* Asbestosis, third stage, complicated by bronchiectasis

infraclavicular region On fluoroscopic examination, the diaphragm on deep inspiration descended 15 centimeters Lipiodol injection showed (Figs 7 and 8) dilatation of the trachea, which was markedly drawn to the right, dilated bronchi in the right upper lobe, while the secondary bronchi in the right and left lower lobes were quite accentuated and appeared dilated A diagnosis was made of asbestosis, third stage, complicated by bronchiectasis, moderately advanced, with no evidence of pulmonary tuberculosis

This case on closer clinical analysis differs from the preceding five in the marked shortness of breath, amounting to a distressing dyspnea and, at times, to orthopnea, in the facial pallor, and emaciation Again, roentgenologically, there is almost an entire absence of the diffuse nodular mottling so characteristic of advanced silicosis Merewether (11), in an examination of 363 asbestos workers, found 26.2 per cent to be affected with asbestosis, and an additional 5.8 per cent showed precursive signs of this disease He furthermore found that "they do not produce a picture of silicosis and have not been shown to be associated with an in-

creased mortality from pulmonary tuberculosis" Comparing asbestosis with silicosis in the radiologic and postmortem examinations, this same author notes that the asbestos type of fibrosis is more delicate, softer, and more diffuse In contradistinction to the dictum of Riddell that pulmonary fibrosis is brought about by any given dust insofar only as this dust contains silica, and to that of Heffernan's hypothesis (7) that asbestos (a silicate) produces fibrosis by being converted into colloidal silica in the pulmonary tissues, Merewether states that "there is evidence that other inorganic dusts containing no free silica may be productive of this fine type of pulmonary fibrosis in varying degrees" A view not dissimilar to that of Merewether is expressed by Pancoast and Pendergrass (12) when they state "There is probably more reason now to regard 'silicosis' as an occupational term rather than a synonym for 'pneumonoconiosis'"

In the differential diagnosis of pneumonoconiosis during the early stages, bronchitis (acute and chronic), and cardiac decompensation have to be ruled out, in the later stages, pulmonary tuberculosis as an independent or complicating disease, also mycotic infections and carcinomatosis of the lungs As an illustration of the difficulty occasionally encountered in arriving at, or excluding, a diagnosis of pneumonoconiosis, it may be pertinent to give another brief case report

Case 7 W A, white male, aged 35, height 5 feet, 8 inches, weight 128 pounds, married, one child living, occupation, farmer and coal miner since discharge from the service At the time of his first admission to the Veterans' Administration Hospital, Memphis, Tenn, Jan 13, 1932, the chief complaints were cramping pains in the right side below the costal margin, vomiting of bitter, yellow bile, also a productive cough, especially at night, a soreness of the chest, which was tight and wheezed at night The patient left hospital the same day against medical advice on account of serious illness at

stead of dry, (2) the introduction of exhaust devices for the reduction of the dust to a minimum (below 10 million particles per cubic foot), and the use of compressed air respirators, allowing the workman to breathe unpolluted air, (3) a physical and roentgenologic examination prior to entry into these hazardous occupations, with yearly check-up, (4) elimination of the tuberculous or tuberculo-silicotic individual from the mines or industries because of the danger of the spread of the tuberculosis infection. Finally, recognized cases of pneumoconiosis in the advanced stage, particularly those associated with tuberculosis, need to be hospitalized. Cases of silicosis or asbestosis complicated by pulmonary tuberculosis with cavitation, as illustrated in Case 5, and showing frequent hemoptyses, need rest treatment, and if these symptoms are unallayed, resort may be had to pneumothorax and phrenicotomy. The latter procedure would suggest itself more readily since, in a large percentage of silicosis cases cited by Russell *et al*, the location of the complicating tuberculous lesion was basal

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Fig 10 Subsequent to aspiration and partial gas replacement shows no change as compared with admission film except that several fluid levels are noted at the right lower base suggestive of encysted effusion. Probable Diagnosis Silico anthracosis with encysted effusion right side (Coal miner and farmer for past 10 years sputum persistently negative for tubercle bacilli, pleural fluid negative for tubercle bacilli or other organisms, guinea pig negative)

demonstration of the curious asbestosis bodies is said to be pathognomonic for this disease, although Cooke (4) demonstrated curious bodies similar to those in asbestosis in a case of silico-anthraxosis. These asbestos bodies have also been demonstrated in the feces of patients suffering from asbestosis and on biopsy by puncture of the lung. Gloyne (6) cautions that these bodies may be incidental and their presence merely an indication of exposure to asbestos dust. However, in the presence of pulmonary fibrosis and a positive occupational history their occurrence should be considered confirmatory. For differentiation of the various types of pneumoconiosis the occupational history, clinical signs, and especially the x-ray findings are requisite.

Prognosis varies with the type and stage of pneumoconiosis, thus Thompson, Brundage, Russell, and Bloomfield (16), investigating the cement industry (calcium dust), found 15 cases of pneumoconiosis in 53 selected cement workers who were examined clinically and by the

x-ray. To quote these investigators "In none of the cases showing pneumoconiosis were there any clinical symptoms of the condition, although the general fibrosis present and its distribution through the lungs were indicative of the condition." These writers caution against comparison of the x-ray findings in one dusty trade with those in another in which the offending dust is of a different chemical composition, stating that "Even when the x-ray films are quite similar in several instances, we cannot be positive that they express the same character of fibrosis or the same degree of physical impairment of the individual." Furthermore, coal miners' lungs (anthracosis), according to Brownlee *et al*, are consistent with working health although associated with diminished vital capacity, loss of weight, and shortness of breath. Cases of silicosis and asbestosis unassociated with pulmonary tuberculosis give a poor prognosis on account of the progressive nature of the fibrosing process, which may continue even after the workman has changed to a non-dusty trade (1), and on account of the liability of circulatory failure incident to hypertrophy of the right heart due to the burden on the pulmonary circulation. In silicosis complicated by pulmonary tuberculosis the prognosis is grave, in asbestosis, only slightly more hopeful. Thus Wood and Gloyne (18), in a study of 57 cases of pulmonary asbestosis, found 10 active cases of tuberculosis, two of them fatal. These workers are of the opinion, however, that obsolescent tuberculosis may remain quiescent in the presence of asbestosis. Silicosis, it is held, lights up any quiescent tuberculous lesions. Gardner's hypothesis (referred to above), if thoroughly confirmed, should militate against employment in the granite industry of individuals who, prior to their entry into this industry, showed roentgenologic evidence of marked calcification of the tracheobronchial lymph nodes.

Treatment of these cases is chiefly preventive in nature. It consists (1) of the adoption of wet drilling methods, in-

having been made previously and the operation undertaken deliberately Bordenheuer was the pioneer in developing panhysterectomy in Germany, and Mary Dixon Jones, unacquainted with Bordenheuer's work, at about the same time (1888) performed the first total abdominal hysteromyomectomy in America Batley, of Atlanta, Georgia, in 1857, suggested removal of the ovaries for non-ovarian conditions Tait excised the uterine appendages to arrest the growth of a bleeding myoma in 1872, and Trenholm adopted this procedure two years later, although he had performed his first hysterectomy in 1873 From 1880 removal of the uterus through an abdominal incision was a well recognized procedure It was more than twenty years later that any other means of treating fibromyoma of the uterus was available

In 1896 the roentgen rays were used therapeutically for cutaneous lesions, and Senn, in 1902 and 1903, reported the use of roentgen rays in the treatment of leukemia Perthes introduced deep therapy in 1903, and Holzknecht and Kienbock established the scientific dosage in 1900 and 1902 In 1904, Foveau de Courmelles began treating uterine fibromyoma by roentgen rays, publishing later the results of this treatment in 53 cases The technique was later perfected by Holzknecht, Witterer, Albers-Schonberg, Garl, and Fraenkel and others, and now roentgen rays are frequently used in the treatment of uterine fibromyoma

In 1905 Abbe reported the first case of uterine fibromyoma in which radium was used in treatment Later Kelly became one of the foremost sponsors for the use of radium in the treatment of uterine fibromyomas, and Clarke, Burnam, and others were the next pioneers in establishing radium as a definite therapeutic agent in the treatment of uterine fibromyoma in carefully selected cases We have now at our disposal myomectomy, hysterectomy, radium, and roentgen rays for the treatment of uterine fibromyoma in cases in which the tumor is producing symptoms and interference seems indicated

Bland-Sutton cited the indications for treatment of uterine fibromyoma in an article written on this subject thirty years ago, and they still remain much the same (1) when the fibroid tumor causes profuse and long-continued menorrhagia, (2) when it is septic or gangrenous, (3) when it is impacted and irreducible and causes pain or retention of urine, (4) when it is growing rapidly or degenerating, softened and diffuent, (5) when a fibroid tumor of the cervix is too large to permit of enucleation through the vagina, and (6) when it complicates pregnancy, delivery, and the puerperium in certain circumstances Bland-Sutton wrote of opening the uterine cavity and extracting the tumor and then suturing the incision, to this operation he applied the term "hysterotomy"

The choice of the type of treatment best suited to the individual case depends on several factors (1) the age and general health of the patient, (2) the size of the tumor and whether it is increasing in size or undergoing degenerative changes, (3) a history of previous pelvic inflammatory disease, or lack of such a history, and (4) the patient's preference In a small group of cases any one of the types of treatment mentioned may be used with equally good results, and in these cases the patient's preference may be considered Some patients have a prejudice against the use of radium and roentgen rays, some prefer the treatment which will give greatest assurance of permanent and complete relief of symptoms, whatever the sacrifice of tissue, some are fearful of all operations Certain patients wish the uterus preserved and the menstrual function disturbed as little as possible, even though they fully understand that more radical treatment may be necessary at some later time

There are generally accepted rules governing the selection of the form of treatment in certain cases Abdominal myomectomy is more conservative than radium or roentgen rays for the woman in the child-bearing period Hysterectomy is

# THE TREATMENT OF UTERINE FIBROMYOMAS<sup>1</sup>

By LEDA J STACY, M D , *Rochester, Minnesota*

Division of Medicine, The Mayo Clinic

AS is well known, uterine fibromyoma is a very common type of tumor, since 12 per cent of all white women and 30 per cent of all negro women aged approximately 50 years have or have had fibromyomas. In many cases the tumors do not cause symptoms and are found in the course of general examination. Even large tumors which are readily palpated on abdominal examination may not cause trouble and the increase in the size of the abdomen may be the only symptom to attract the patient's attention. Usually, however, the large tumors cause discomfort by pressing on the bladder, or by producing a sense of fullness and weight in the abdomen. Menorrhagia and irregularity of the menstrual cycle, with resulting secondary anemia, are the chief symptoms for which the patient seeks relief. Pelvic pain, although not severe, is present in a large proportion of the cases. In the 320 histories used as a basis for this study, menorrhagia was recorded in 205 (64.05 per cent) of the cases, metrorrhagia in 74 (23.12 per cent), dysmenorrhea in 150 (46.87 per cent), and intermenstrual pelvic pain in 70 (21.87 per cent). Pain occurred in 55 per cent of the cases in which, at the time of operation, the fibromyoma was found to be undergoing degenerative changes.

Earlier writers noted an increase of the conceded normal percentage of infertility among those patients having fibroid tumors of the uterus and the presence of these tumors has been considered to be one of the etiologic factors in sterility. In the series of 320 case histories here reviewed, 268 of the patients were married women, of whom 75 (27.98 per cent) had not been pregnant, and 9 per cent had had miscarriages only. The normal percentage of

sterile marriages is considered to be about 10 to 15.

The evolution of treatment of uterine fibromyoma is an interesting chapter in medical history. Vaginal hysterectomy was performed for an extruding organ as early as 1507, when Berengarius, of Bologna, performed the first recorded partial vaginal hysterectomy. In 1600, Schenk, of Grobenburg, reviewed and reported 36 cases in which vaginal hysterectomy was performed, but the operations were done for removal of a prolapsed uterus or for carcinoma of the uterus. The earlier writers did not believe that any fibroid tumor, except a polypus, could be removed. In 1825 John Lizars, and some time before 1831 Nathan Smith, opened the abdomen for what was thought to be an ovarian tumor, but they abandoned the operation when the tumor was found to be a fibromyoma. In 1842 Amussat reported two cases in which vaginal myomectomy was performed for submucous fibromyoma, an earlier operation having been done by him in 1840, which is the first record of a deliberate attempt to remove a uterine tumor. Atlee performed the first successful abdominal myomectomy in 1844, and Kimball in 1853, the first abdominal myomectomy with deliberate intention, the diagnosis having been made previous to operation. Clay is thought to have performed the first abdominal hysteromyomectomy in 1843, the diagnosis being ovarian tumor. Three years later, in the year 1846, Bellinger performed a deliberate hysteromyomectomy for a fibroid tumor of the uterus. The patient died five days later of peritonitis. Burnam, of Lowell, Massachusetts, in 1853 performed the first successful abdominal hysteromyomectomy. Koeberle, of Strassburg, in 1861, performed the first successful hysteromyomectomy in Europe, the diagnosis

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they became regular but profuse, and of eight (13.33 per cent) the periods became irregular. Menopause occurred several years after operation in two cases. The general health of 46 of the 60 living patients (76.66 per cent) was reported to be good, and that of 14 (23.33 per cent) to be fair. Nine of the living patients (15 per cent) reported that tumors had formed subsequently, for which one patient had received treatment by roentgen rays, one by radium, and seven by surgical operation. Three of those who underwent surgical operation had the uterus removed from five to seven years after myomectomy, one had a chemical hysterectomy two years after myomectomy, one had a curettement and treatment by roentgen rays five years after myomectomy, one had curettement with removal of a small tumor three and a half years after myomectomy, and one had curettement nine months after myomectomy. Of the 55 women who had not ceased menstruating, 13 (23.63 per cent) became pregnant after the operation, some had more than one child, giving a total of 22 children.

*Hysterectomy*—Of the 80 patients who underwent abdominal hysterectomy, 68 (85 per cent) were aged forty years or more. Menorrhagia was one of the chief complaints of 59 patients (73.75 per cent), and 23 (28.75 per cent) of the 80 patients had secondary anemia, five had undergone myomectomy elsewhere before they came to the clinic, and five had had radium treatment elsewhere without control of symptoms. Indications for operation in this group were as follows: the presence of a large tumor in 62 (77.50 per cent) of the cases, the possibility of an ovarian tumor being present in 10 (12.50 per cent) of the cases, and a history suggestive of malignancy in eight (10 per cent) of the cases. There was a history of previous pelvic infection in nine (11.25 per cent) of the cases and the cervix was badly diseased in 20 (25 per cent). At the time of operation, multiple fibroid tumors were found in 74 (92.50 per cent) of the cases, associated with salpingitis in 57 cases,

and with bilateral oophoritis in 37 cases. One patient died in hospital four days after operation, from general peritonitis, giving a mortality rate attributable to the operation of 1.25 per cent. Five patients died subsequently, one of pneumonia six years later, three of unknown cause, and one following an operation for obstruction of the bowel, performed elsewhere, almost three years after the hysterectomy.

The condition of 67 patients who underwent abdominal hysterectomy has been ascertained. Five had died, as has been said, and of the remaining 62, 44 (70.96 per cent) have reported that they are in general good health, 17 (27.41 per cent) that they are in fair health, and one (1.61 per cent) that she is in poor health. Thirty-one patients of the 62 (50 per cent) stated that they were more nervous following operation than previous to operation. Thirteen of the 62 patients (20.96 per cent) stated that they had not experienced hot flashes since the operation, whereas 40 (64.51 per cent) had experienced them. Forty-seven patients (75.80 per cent) reported that there had been no pelvic discomfort following the operation, whereas seven (11.29 per cent) had experienced some pelvic pain. Forty-three patients (69.35 per cent) had gained weight. None of these patients had undergone subsequent operations.

*Radium*—Of the 80 patients treated with radium, 10 (12.50 per cent) were between thirty and forty years of age, one was aged less than thirty years, 69 patients (86.25 per cent) were aged forty years or more. In this group of 80 patients, 71 (88.75 per cent) complained of menorrhagia, 33 (41.25 per cent) of metrorrhagia. Surgical operation was considered inadvisable because of hypertension in six cases (7.50 per cent), because of obesity in six, because of previous phlebitis in one, because of carcinoma elsewhere in the body in two, and because of extreme nervousness in four. Two patients had syphilitic aortitis, one had renal calculi, and one was paralyzed. Preliminary dilatation and curettage was done in 49 (61.25 per cent) of the cases. Nine

preferable if the tumor is large, if it is increasing in size rather rapidly, if it is producing symptoms indicative of complications such as degeneration or torsion of the pedicle, or if curettage discloses evidence of submucous fibromyoma. The effect of radium and roentgen rays is not immediate and if there is profuse menstruation and marked secondary anemia, transfusion, and then hysterectomy, is often a preferable procedure. Total abdominal hysterectomy is indicated if a badly lacerated or infected cervix is associated with the fibromyoma. In cases in which there is evidence of pelvic infection or a history of previous infection, radium is definitely contra-indicated. Treatment by roentgen rays is thought by many to be a safe procedure in cases of chronic pelvic infection, but as a rule hysterectomy would seem to be safer. Hysterectomy is indicated if there is a possibility of malignancy of the body of the uterus. Radium offers a simple and effective means of treatment for the patient aged more than 37 years, if the fibromyoma has increased the size of the uterus approximately to that of a uterus after four months of gestation, or if the uterus is small and fibrous and the patient has menorrhagia, provided, always, that there is no history and no local evidence of pelvic infection. Treatment by roentgen rays is most useful in reducing the size of the tumor and causing cessation of menstruation in cases of large uterine tumor, when there is a definite contra-indication to surgical operation, such as is presented by obesity, hypertension, cardiac lesion, and nephritis. It also controls the bleeding in cases of a fibrous uterus with menorrhagia. Curettage for diagnosis should precede the use of radium and roentgen rays unless the procedure is thought to be unwise because of the patient's general condition. I believe that in a large percentage of cases in which results are unsatisfactory following the use of radium and roentgen rays, the lesions are submucous fibroid tumors.

#### PRESENT INVESTIGATION

A comparison has been made of the results of treatment by myomectomy, by hysterectomy, by radium, and by roentgen rays. As has been stated, 320 patients are included in the present study, 80 of whom were subjected to myomectomy, 80 to hysterectomy, 80 to treatment by radium, and 80 to treatment by roentgen rays.

*Myomectomy*—Of the 80 patients who underwent abdominal myomectomy, 73 (91.25 per cent) were aged under 40 years. Thirty-five patients (43.75 per cent) had menorrhagia, 10 (12.50 per cent) had metrorrhagia, 47 (58.75 per cent) complained of dysmenorrhea, and 24 (30 per cent) had intermenstrual pelvic pain. Fifty-seven patients were married, 30 (52.63 per cent) of whom had not been pregnant, and 10 (17.54 per cent) of whom had had miscarriages only.

Myomectomy was selected as the type of treatment indicated in this series of 80 cases, for the following reasons: (1) because of the patient's youth in 57 cases (71.25 per cent), (2) because of the presence of a single tumor in 27 cases (33.75 per cent), and (3) because 18 (22.50 per cent) of the patients definitely desired children. Seven women were pregnant at the time of operation—one of these miscarried on the fourth day after operation. Thirty-one of the 80 patients (38.75 per cent) had single tumors, 18 (22.50 per cent) of the tumors showed degenerative changes. There were no deaths following myomectomy.

Replies to questionnaires have been received concerning 62 of the 80 patients who underwent abdominal myomectomy. Two patients had died. The cause of death was not given in one case, and in the other, malignancy of the pelvic organs was reported. This patient had undergone curettage for diagnosis preceding the application of radium. Following operation the menstrual periods of 43 of the 60 living patients (71.66 per cent) became regular and normal, of four (6.66 per cent)

they became regular but profuse, and of eight (13.33 per cent) the periods became irregular. Menopause occurred several years after operation in two cases. The general health of 46 of the 60 living patients (76.66 per cent) was reported to be good, and that of 14 (23.33 per cent) to be fair. Nine of the living patients (15 per cent) reported that tumors had formed subsequently, for which one patient had received treatment by roentgen rays, one by radium, and seven by surgical operation. Three of those who underwent surgical operation had the uterus removed from five to seven years after myomectomy, one had a chemical hysterectomy two years after myomectomy, one had a curettement and treatment by roentgen rays five years after myomectomy, one had curettement with removal of a small tumor three and a half years after myomectomy, and one had curettement nine months after myomectomy. Of the 55 women who had not ceased menstruating, 13 (23.63 per cent) became pregnant after the operation, some had more than one child, giving a total of 22 children.

*Hysterectomy*—Of the 80 patients who underwent abdominal hysterectomy, 68 (85 per cent) were aged forty years or more. Menorrhagia was one of the chief complaints of 59 patients (73.75 per cent), and 23 (28.75 per cent) of the 80 patients had secondary anemia, five had undergone myomectomy elsewhere before they came to the clinic, and five had had radium treatment elsewhere without control of symptoms. Indications for operation in this group were as follows: the presence of a large tumor in 62 (77.50 per cent) of the cases, the possibility of an ovarian tumor being present in 10 (12.50 per cent) of the cases, and a history suggestive of malignancy in eight (10 per cent) of the cases. There was a history of previous pelvic infection in nine (11.25 per cent) of the cases and the cervix was badly diseased in 20 (25 per cent). At the time of operation, multiple fibroid tumors were found in 74 (92.50 per cent) of the cases, associated with salpingitis in 57 cases,

and with bilateral oophoritis in 37 cases. One patient died in hospital four days after operation, from general peritonitis, giving a mortality rate attributable to the operation of 1.25 per cent. Five patients died subsequently, one of pneumonia six years later, three of unknown cause, and one following an operation for obstruction of the bowel, performed elsewhere, almost three years after the hysterectomy.

The condition of 67 patients who underwent abdominal hysterectomy has been ascertained. Five had died, as has been said, and of the remaining 62, 44 (70.96 per cent) have reported that they are in general good health, 17 (27.41 per cent) that they are in fair health, and one (1.61 per cent) that she is in poor health. Thirty-one patients of the 62 (50 per cent) stated that they were more nervous following operation than previous to operation. Thirteen of the 62 patients (20.96 per cent) stated that they had not experienced hot flashes since the operation, whereas 40 (64.51 per cent) had experienced them. Forty-seven patients (75.80 per cent) reported that there had been no pelvic discomfort following the operation, whereas seven (11.29 per cent) had experienced some pelvic pain. Forty-three patients (69.35 per cent) had gained weight. None of these patients had undergone subsequent operations.

*Radium*—Of the 80 patients treated with radium, 10 (12.50 per cent) were between thirty and forty years of age, one was aged less than thirty years, 69 patients (86.25 per cent) were aged forty years or more. In this group of 80 patients, 71 (88.75 per cent) complained of menorrhagia, 33 (41.25 per cent) of metrorrhagia. Surgical operation was considered inadvisable because of hypertension in six cases (7.50 per cent), because of obesity in six, because of previous phlebitis in one, because of carcinoma elsewhere in the body in two, and because of extreme nervousness in four. Two patients had syphilitic aortitis, one had renal calculi, and one was paralyzed. Preliminary dilatation and curettage was done in 49 (61.25 per cent) of the cases. Nine



patients (11 25 per cent) received less than 1,000 mg -hrs of radium, 56 (70 per cent) between 1,000 and 2,000 mg -hrs, 15 (18 75 per cent) 2,000 mg -hrs or more

Of the 73 patients traced, who received treatment by radium, 68 (93 15 per cent) were living, whereas five (6 84 per cent) had died subsequent to the treatment (two of these had carcinoma elsewhere in the body at the time of treatment, two died from "stroke," and one of unknown cause) Of the 68 living patients, 56 (82 35 per cent) reported their general health to be good, eight (11 76 per cent) stated that their general health was not improved, and seven patients (10 29 per cent) reported the presence of pelvic pain since the treatment Fifty-seven (83 82 per cent) of the 68 patients ceased menstruating following treatment, and seven (10 29 per cent) did not cease menstruating One patient had ceased menstruating before the application of radium, and three patients did not mention the menstrual history Of the seven patients who did not cease to menstruate, one, aged 35 years, received 600 mg -hrs and the menstrual flow became normal in quantity but the periods were not regular One patient, aged 25 years, received 150 mg -hrs of radium, and the periods became regular and normal Another patient, aged 42 years, was given 1,200 mg -hrs of radium, whereupon she ceased to menstruate for seven months and then had a return of periods for a time However, she had not menstruated for two years at the time of her reply Another woman, 37 years of age, was given 1,000 mg -hrs, and stopped menstruating for six months, then menstruation became normal for a while but at the time of the reply occurred only occasionally One patient subsequently was given treatment by roentgen rays and operation was done subsequently on five patients

Of these five patients, one, aged 45 years, received 1,000 mg -hrs of radium and underwent hysterectomy four years later because of profuse and irregular menstruation A second patient, aged 33

years, received 1,000 mg -hrs, and was operated on two months later for drainage of a pelvic abscess, and three months after that, left oophorectomy was performed for an abscess A third patient, six years after treatment, had an intra-uterine and cervical polyp removed for slight vaginal bleeding, and a fourth underwent hysterectomy two years later, for diffuse adenomyoma with necrosis and a hemorrhagic cystadenoma of the ovary A fifth patient underwent curettement for diagnosis a year and a half after treatment with radium because of a slight vaginal discharge

Of the 68 patients who were living, 50 (73 52 per cent) reported the presence of hot flashes, and 32 (47 05 per cent) reported increase in nervousness following the treatment, whereas 29 (42 64 per cent) definitely stated that increased nervousness had not been noted Forty-four (64 70 per cent) had gained weight, and 41 (60 29 per cent) had gained strength

*Roentgen Rays*—Of the 80 patients who received treatment by roentgen rays, 12 (15 per cent) were aged less than forty years, 39 (48 75 per cent) were between forty and forty-nine years, 29 (36 25 per cent) were fifty years or more, one patient was aged seventy-six years, and 11 patients (13 75 per cent) had passed the menopause Three patients had been operated on elsewhere for a tumor of the uterus, and 18 (22 50 per cent) had undergone other pelvic operations Forty (50 per cent) complained of menorrhagia, 12 (15 per cent) complained of metrorrhagia, and 13 (16 25 per cent) had pain between menstrual periods Surgical procedures were contra-indicated in four cases in this group because of malignancy elsewhere in the body, it was contra-indicated in one case because of phlebitis, in one because of hyperthyroidism, and in one because of malignant hypertension

Information has been received concerning 63 of the patients who were treated by roentgen rays for fibromyomas Of the 13 who are dead, the cause of death of five is not known, one died of submaxillary abscess and cerebral hemorrhage,

TABLE I—RESULTS

State of health after treatment and incidence of secondary treatment	Treatment			
	Myomectomy, percentage of 60 living	Hysterectomy, percentage of 62 living	Radium, percentage of 68 living	Roentgen rays, percentage of 50 living
Good	76 66	70 96	82 35	90 0
Fair	23 33	27 41		
Not improved		1 61	11 76	10 0
Menstruation ceased		100 00	83 82	78 0
Menstruation became normal	71 66 (profuse 6 66)		2 93	5 12
Hot flashes		64 51	73 53	62 0
Nervousness		50 00	47 05	30 0
Pain in the pelvis		11 29	10 29	20 0
Subsequent operation necessary	11 66		7 35	4 0
Subsequent roentgen-ray treatment	1 66		1 47	2 0
Subsequent radium treatment	1 66			2 0

one of chronic endocarditis and mitral stenosis, one of nephritis and "heart trouble," one of diabetes, one of arsenic poisoning, one of carcinoma of the breast, and two of "gradual decline"—one of these in coma. Of the 50 patients who were still living at the time of the inquiry, 45 (90 per cent) reported their general health to be good, and five (10 per cent) reported that it was not improved. Thirty-one patients (62 per cent) reported the presence of hot flashes. Ten patients (20 per cent) reported that there had been pelvic pain and 15 patients (30 per cent) reported increased nervousness. Of the 39 who ceased to menstruate, 23 (58.97 per cent) ceased immediately following treatment, 11 (28.20 per cent) in from one to six months after treatment, and the time of cessation was not stated in five cases (12.82 per cent). Menstruation was resumed in two cases, and in three the menstrual history subsequent to the treatment was not mentioned. In two cases roentgen-ray treatment, and radium and curettement, and radium, respectively, were applied. In three cases operation was performed subsequently. Hysterectomy had been performed on one patient one and a half years later—there had been no symptoms in this case, but on examination the tumor was found to be soft and had not decreased in size. One patient was operated on elsewhere, the nature of the operation not being known. One

patient had a tumor of the left ovary, reported to be a carcinoma of the hypernephroma type twelve years after roentgen-ray treatment, the pelvic examination at the time of operation had been negative. One patient, who had ceased menstruating before treatment, stated that the tumor was enlarged and she felt that operation should be done. Sixty-eight (85 per cent) of the 80 patients had been given one course of roentgen-ray treatment, a course consisting of two or three exposures to the abdomen and to the back, depending on the size of the tumor and the weight of the patient.

#### SUMMARY

Patients having small fibromyomas which do not cause symptoms should be examined semi-yearly to detect any change in size or consistence of the tumor, and must be warned regarding the importance of any change in the menstrual cycle.

The choice of treatment in cases of uterine fibromyomas that produce symptoms depends on the age and general condition of the patient, the size of the tumor, and symptoms.

Myomectomy is the most conservative treatment. A woman who is in the child-bearing period of life should be allowed to choose this form of treatment, pro-

patients (11 25 per cent) received less than 1,000 mg-hrs of radium, 56 (70 per cent) between 1,000 and 2,000 mg-hrs, 15 (18 75 per cent) 2,000 mg-hrs or more

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# THE BEHAVIOR OF THE INTERVERTEBRAL DISC IN CERTAIN SPINE LESIONS<sup>1</sup>

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From the Departments of Roentgenology and Pathology of City Hospital and Western Reserve University

AS an involvement of the intervertebral disc often occurs in spinal lesions, a brief review of some of the compiled data concerning its function, anatomy, and vascularization may be conveniently interpolated here

The intervertebral disc consists of the nucleus pulposus and annulus fibrosus. The soft mass of the nucleus is usually eccentrically situated and is surmised to be the remnant of the chorda tissue of the embryonic spine. It consists of a mass of watery fibrous strands arranged in numerous wavy bundles among which spindle-shaped connective tissue cartilage cells and chorda rests are scattered. Some of these bundles terminate in villous processes. There is a small antrum, first described by Luschka, in the mid-portion of the nucleus, which contains a synovial fluid-like substance. The antrum is multilocular and consists of small gaps between the fibrils.

The fibrous ring consists of a system of lamellæ composed of fibrocartilage. These fibers are coarser than those of the nucleus, they sweep around the nucleus and form a definite capsule for it. Above and below, the lamellæ of the fibrous ring strongly attach themselves to the cartilage plates, which consist of layers of hyaline cartilage, that fit into the uneven grooved surface of the upper and lower bone plate of the vertebral body.

Schmorl (29) in some of his earlier publications stated that the discs did not contain blood vessels. However, Boehmig's (5), Uebermuth's (36), and Smith's (35) investigations showed that there were many nutritive spaces in the nucleus pulposus and annulus fibrosus up to the

end of the growing period, and this fact was later confirmed by Schmorl (30) also.

At the end of the growing period these blood vessels start to obliterate, which obliteration is subject to individual variations, as it occurs sooner in some individuals and later in others, somewhere between the ages of 22 and 30. The obliterated blood vessels, according to Boehmig (6), are replaced by a cartilaginous substance which takes up the form of the previous blood vessels and its ramifications can be easily recognized. They are called "blood vessel scars" and are supposed to play an important rôle in the development of some of the cartilage nodes (Schmorl's *Knorpelknoetchen*).

As the blood vessels obliterate, the nourishing material of the disc is received from the vertebral bodies through diffusion. Schmorl (30) demonstrated that the upper and lower surfaces of the vertebral body resemble a sieve. The cartilage plate is firmly attached to this sieved surface, so that the nourishing fluid has to pass through it on its way to the disc, and *vice versa*. As the cartilage becomes older this diffusion undergoes a certain degree of degeneration, this being the reason why an elastic and well maintained disc is so seldom found in older individuals.

The general consensus of opinion is that the mode of infection in spinal lesions is by the hemotogenous route, the lesion being a metastatic process from some primary focus. However, there are some who believe that the lymphatic system is the route by which infection takes place.

The discs form approximately one-fourth of the total length of the vertebral column and vary in vertical thickness in several regions, being thickest in the lumbar and thinnest in the upper thoracic region. Ja-

<sup>1</sup> Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov 28-Dec 1, 1932

vided it is made clear to her that a radical operation may be necessary later

degeneration of the tumor or the presence of a submucous fibroid

Hysterectomy is indicated in cases of previous pelvic infection, in cases in which the history suggests complications, as

Roentgen-ray and radium treatment in carefully selected cases give excellent results in a high percentage of cases

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Primary metastatic tumors in the disc never have been observed by Schmorl (30), but he saw metastatic tumors extend into the disc from the involved

vertebral bodies, we routinely examine its width and contour carefully, as its behavior may betray an existing vertebral lesion not of sufficient size to cast a defi-



Fig 3 Tuberculous spondylitis Anteroposterior postmortem film showing some bone destruction and considerable amount of new bone production along the left borders of the first, second, and third lumbar vertebrae



Fig 4 Postmortem lateral view of the same case as shown in Figure 3, showing the vertebral end-plates to be smooth and the intervertebral spaces to be of normal width. The bone destructive process is situated along the anterior borders of the vertebral bodies

vertebral body The disc may show narrowing on the roentgen film in cases in which, after destruction of the end plate by metastatic tumors, some of the disc tissue herniates itself into the vertebral body

As slight pathologic processes of the disc—most satisfactorily seen in the lateral view—can be easier visualized roentgenologically than early involvements of the

nite shadow Adib Chasin (8), in an instructive experiment, demonstrated that in the formation of a roentgenogram the compact layer of the vertebral body has the greatest importance If the entire spongiosa is removed and the defect caused by the removal is filled with paraffin, which is of the density of the neighboring soft tissues, no defects can be recognized on the roentgenograms of the specimen, but even defects of the compact substance cannot be recognized if they measure only

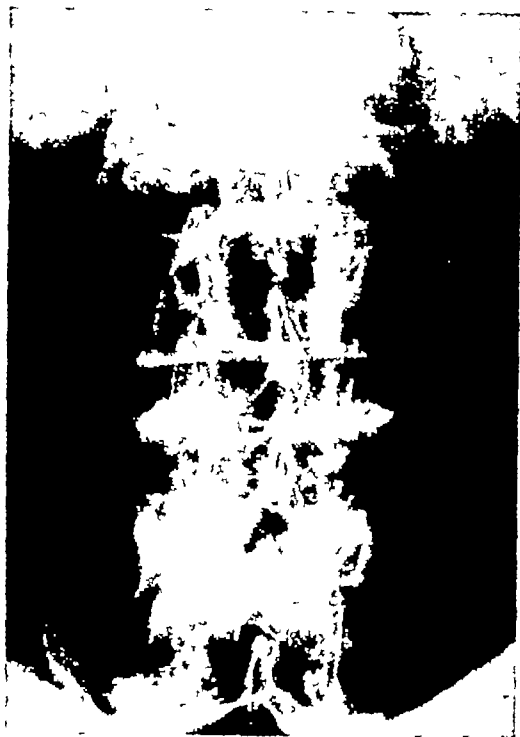


Fig 1 Tuberculous spondylitis with a completely collapsed third lumbar vertebral body and well maintained intervertebral spaces, giving the appearance of a metastatic tumor

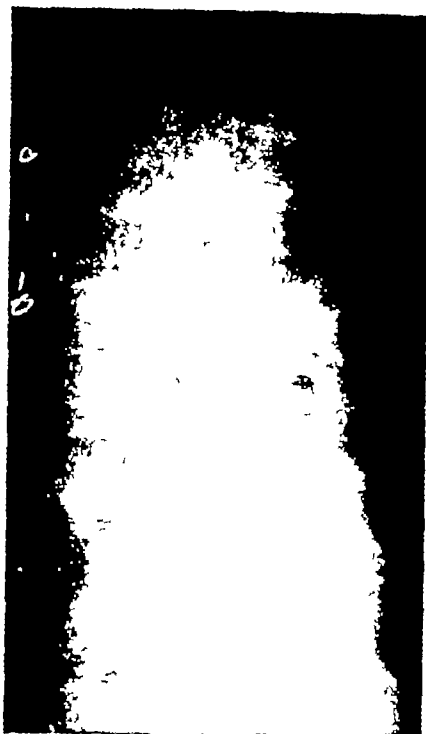


Fig 2 Tuberculous spondylitis showing the collapsed and flattened third lumbar vertebral body and increased width of the disc above and below

cobi (15), examining the vertebrae of 102 persons between the ages of 18 and 87, found the smallest values for the disc in the upper thoracic region. He found the proportion of the discs to the vertebral bodies approximately 1:1.5 in the thoracic, 1:3 in the lumbar region.

The individual discs also show differences in width, mainly between the anterior and posterior portions, which differences are most marked in the lumbar region. The fifth intervertebral disc is often wedge-shaped, influencing the lumbosacral angle.

The function of the disc does not depend on its arrangement as a joint, but upon the physical differences between its constituents and the formation of fibers of the annulus. The nucleus is highly compressible and elastic, the annulus relatively inelastic. The discs thus form delicate buffers between the vertebrae, absorbing

shocks transmitted through the spine. Consequently they are rudimentary diarthroidal joints, allowing a small degree of movement in all directions, and are important in imparting flexibility to the spine.

The question whether the intervertebral disc can be the primary seat of a disease or whether its involvement is always secondary to an involvement of the bone is also much debated. Schmorl thinks that a primary disease of the disc is possible only in young adults, as they possess a vascularized disc. In grown-ups the disc may be primarily involved only in cases in which, through tears of the hyaline plate, blood vessels enter the disc, or in which, on the basis of a cartilage node formation, vascularization has occurred. He observed a case in which a secondarily vascularized second lumbar disc was the seat of a small abscess in a patient suffering from pyemia subsequent to a Vincent's angina.

tuberculous spondylitides and vertebral fractures, arrived at the conclusion that the outlines of the intervertebral space are irregular and moth-eaten in every case of vertebral tuberculosis

bone atrophy, changes of the physiologic curve of the involved area, and paravertebral abscess formation are well known

However, there are cases of spinal tuberculosis in which the intervertebral space



Fig 7 Metastatic tumors of the sixth and seventh dorsal vertebrae, with marked destruction of the neighboring surfaces of the vertebral bodies and disappearance of the intervertebral space. Note stoppage of lipiodol in the subdural space at the site of the lesion

Only in the most recent years has opinion begun to be voiced that although these facts are true in the great majority of instances, in case of doubt the behavior of the disc cannot be used as a diagnostic sign, because it may be narrowed in metastatic tumors and well maintained in tuberculosis

In order to clarify our conception of the rôle of the disc, a large number of spine roentgenograms were reviewed, and the reviewed material contained some answers to the above questions

#### TUBERCULOUS SPONDYLITIS

The typical roentgenologic appearance of the tuberculous spondylitis, with destruction of parts of the vertebral bodies, narrowing of the intervertebral space, relatively little or no new bone production,

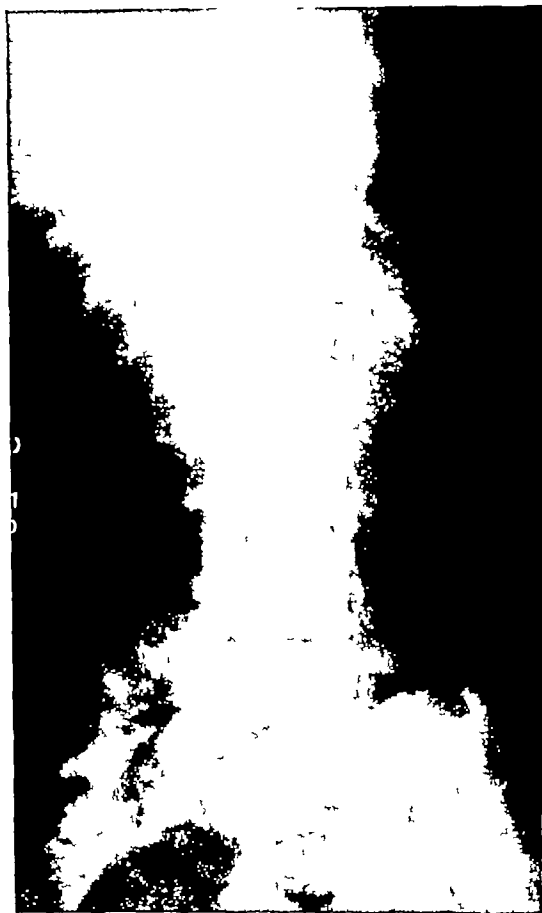


Fig 8 Metastases to the ribs, vertebrae, and pelvic bones from a carcinoma of the breast. Note the marked narrowing of the intervertebral discs between the eighth and ninth, ninth and tenth dorsal vertebrae between the twelfth dorsal and first lumbar, between the first and second, second and third lumbar vertebrae due to herniation of the discs

appears to be well maintained on the roentgenogram, despite an advanced bony lesion. Ellmer (11) in his material found similar occurrences. Freund (13) mentions the fact that at times, despite the collapse of two neighboring vertebrae, the disc may remain wide—in one of his cases it was even wider than the neighboring vertebrae. A tumor was first suspected in this case, but the patient also had a



0.5 sq cm in size and from two to three mm in depth. Cylindrical defects which measure 1 cm in diameter and traverse all the layers of the vertebral body can

be recognized only in those projections in which the axis of the defect is parallel to the axis of the central ray. Consequently the vertebral lesion has to be quite large to be recognizable.

bral disc as a good sign for tuberculosis, as against a localized metastatic tumor, in which case the disc is supposed to be found intact. Sicard (32) and his co-

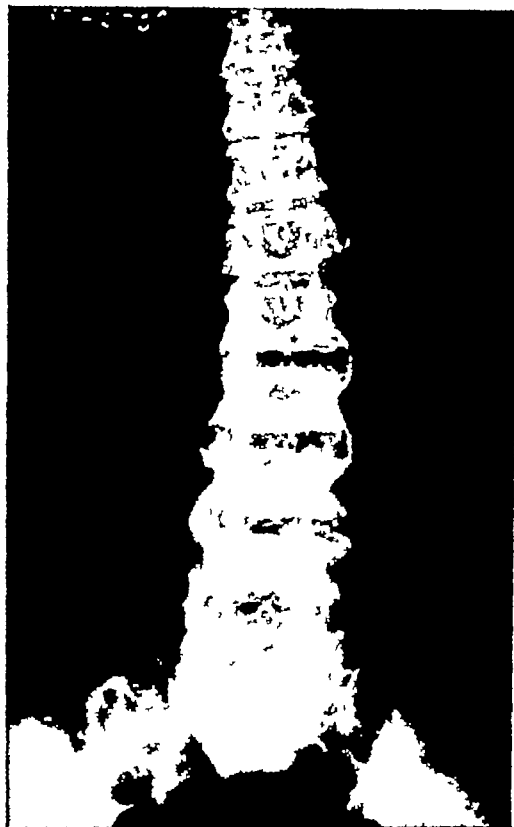


Fig 5 Tuberculous spondylitis. Anteroposterior postmortem film showing larger spurs along the left borders of the lumbar vertebral bodies and a few small ones along their right borders. The intervertebral spaces appear to be well maintained and the appearance is of a deformative spondylosis rather than of a tuberculous process.

The question is, that if change in the width of the intervertebral space is an index of a vertebral lesion, can this change be evaluated in the differential diagnosis of the great variety of spinal diseases?

The text-books and many publications consider the narrowing of the interverte-



Fig 6 Lateral view of the same case as shown in Figure 5. A removed section of the lumbar vertebra showing that, despite a complete destruction of the disc, the intervertebral spaces appear to be well maintained. The destruction of the disc could not be visualized on the premortem films. Note the diffuse osteitis of the vertebral bodies and arches.

workers make the definite statement that metastatic tumors represent a purely osseous disease and the discs are well maintained even in an advanced stage of the disease. On the other hand, Sgalitzer (31) emphasized the narrowing of the disc in all of his cases, as an important diagnostic sign for tuberculous spondylitis. Doubt (9), in recent publications, also considers the narrowing of the disc as an important finding in the diagnosis of tuberculous spondylitis.

Baetjer and Waters (3) emphasize that in tuberculous spondylitis there is an obliteration of the joint space, with involvement of the body and with no evidence of new bone production, whereas in non-tuberculous cases there is new bone production and no obliteration of the joint spaces.

Rostock (28), examining 364 cases of

portant finding in tuberculous spondylitis. The roentgenologic diagnosis of metastatic tumor was made. At postmortem examination the third lumbar vertebra

chronic caseous tuberculous epididymitis, funiculitis, and seminal vesiculitis.

Figures 3 and 4 are postmortem films of a lumbar vertebral column showing con-



Fig 11 Typhoid spondylitis. Roentgenogram taken 39 days later shows tremendous new bone production between the neighboring surfaces of the first and second lumbar vertebrae, mainly on the left.

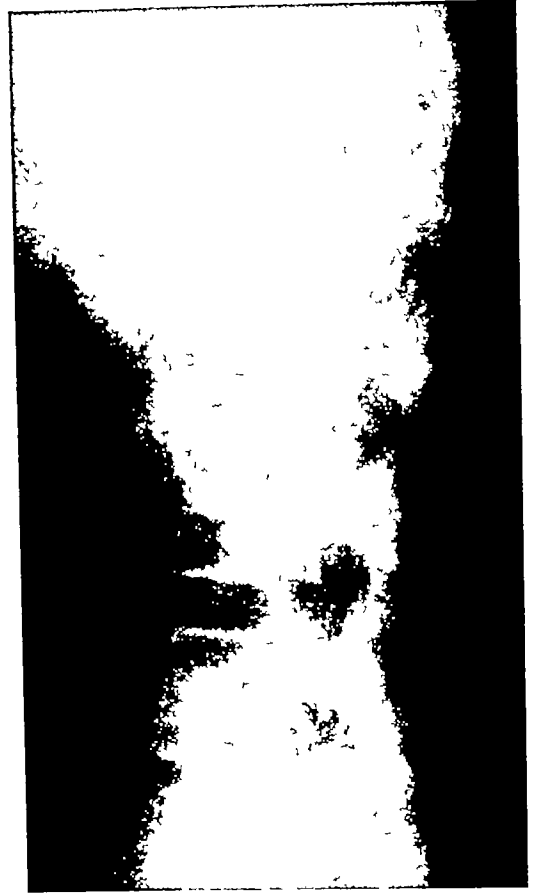


Fig 12 Lateral view shows the disc to be narrower than at the previous examination. The neighboring vertebral surfaces of the first and second lumbar vertebrae show evidence of bone condensation.

was found to be completely collapsed and its substance to be replaced by a yellowish necrotic material, so that the vertebral body showed several circumscribed yellowish areas in the region of the spongiosa. The fourth lumbar vertebra showed only a slight destruction in its upper portion. The discs contained a large amount of yellowish granulating tissue. The diseased vertebrae were surrounded by a small paravertebral abscess containing a few calcified foci. The smear from the pus was positive for tubercle bacilli. Besides the tuberculous spondylitis the patient also had a

considerable amount of irregular bone destruction throughout the left borders of the first, second, and third lumbar vertebrae. The left borders of these vertebrae are surrounded by large irregular spurs. There is a large spur between the neighboring borders of the anterior parts of the second and third lumbar vertebrae. There is evidence of bone destruction on the anterior surfaces of the first and second lumbar vertebrae also. The intervertebral spaces show no narrowing and the

paravertebral abscess, which was tapped. According to the author, such wide gaps between destroyed vertebrae can be understood only in cases in which the patient

tumor. The third lumbar vertebral body is completely collapsed by a bone destructive process, measuring about one-fourth of the width of the neighboring vertebrae.



Fig 9 Early typhoid spondylitis showing a slight left scoliosis in the anteroposterior view



Fig 10 Lateral view taken at the same time as Figure 9 showing a narrowing of the first lumbar intervertebral space. The neighboring surfaces of the first and second lumbar are moth eaten in appearance

is bedridden and has a marked rigidity of the back muscles. Besides, the disc must be filled with some material, most commonly granulation tissue. In his case a sequestrum was seen in the intervertebral space.

Another explanation may be that the paravertebral abscess exerts such a high pressure that it keeps the neighboring vertebral bodies apart. There are no manometric measurements of such abscesses, but occasionally during tapping one sees the pus evacuating under high pressure.

Figures 1 and 2 represent the roentgenograms of a tuberculous spondylitis simulating the appearance of a localized metastatic

Both the anteroposterior and lateral views show a well maintained intervertebral space between the second and third lumbar and an increased width of the intervertebral space between the third and fourth. There are a few bone fragments in the soft tissues around the destroyed vertebra. Despite the marked destruction, there is no change in the physiologic curve of the vertebral column, which, according to Sgaltzer, is a constant and im-

is, the intervertebral spaces were not narrowed, despite a proven tuberculous spondylitis. In the first case they were even wider than the neighboring discs, due to a large amount of granulating tissue which apparently held apart the vertebral bodies. This patient's roentgenograms yielded the typical appearance of a metastatic tumor. There were areas of calcification situated so close to the bone that they suggested bone debris rather than calcification. The clinicians were more correct than the roentgenologist, for, being unbiassed, they did not consider the widening of the discs contradictory to tuberculosis, possibly not having been influenced by the dogmatic roentgenologic postulate of the narrowed intervertebral space. The clinical evidence of tuberculous prostatitis and epididymitis justified them in looking upon the vertebral lesion as of a similar etiology.

In the third case, despite the liquefaction of the discs, the intervertebral spaces were not narrowed, this lack of collapse evidently being due to the large hypertrophic spurs that overbridged the intervertebral spaces. An unusual number of the discs and vertebral bodies were involved in this case. The involvement of two or three vertebrae in tuberculous spondylitis is common, as are multiple lesions of the vertebral column, though the involvement of the entire lumbar column is rare. The bones were not atrophic and the roentgenologic appearance was quite suggestive of a spondylosis deformans, produced by degenerative changes rather than by an infectious process, although one would have expected a more marked lipping and deformity of the vertebral bodies in an advanced spondylosis.

Despite the general belief, areas of new bone production around tuberculous vertebrae are not uncommon, mainly in slowly developing benign cases, but such a marked overbridging of tuberculous vertebrae as this case shows is rare. One can not but think that this case is not a clear-cut tuberculous spondylitis and that the excess bone production was partly caused

by the other infectious organisms found in the discs.

The intervertebral discs of the second patient's vertebrae were not examined

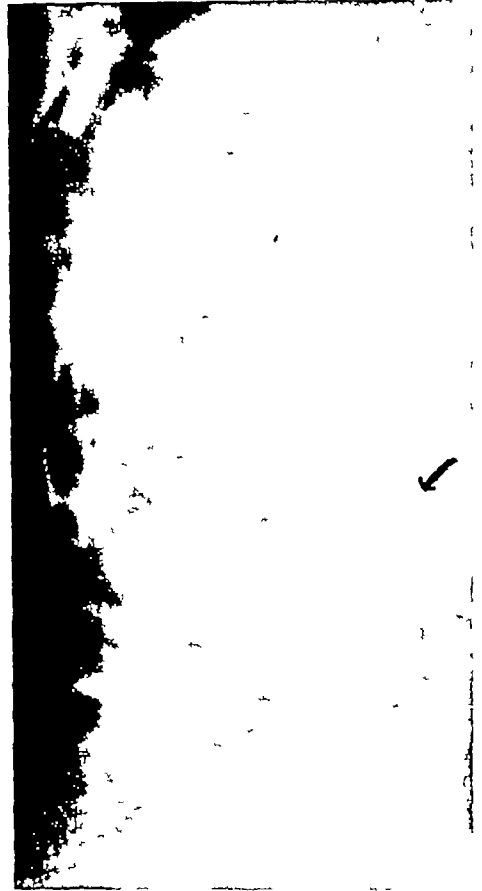


Fig 14 Lateral view showing a marked narrowing of the disc and osteosclerosis of the neighboring surfaces of the first and second lumbar vertebrae. Same case as shown in Figure 13.

pathologically, but on the roentgenograms the discs did not appear to be narrowed, and there was a large amount of new bone formation around the borders of the involved vertebrae. This is much in contradiction of Baetjer and Waters' (3) statement that new bone formation does not occur in non-tuberculous spondylitis.

#### METASTATIC TUMORS

The most common appearance of localized metastatic tumors is a wedge-shaped

proximal and distal surfaces of the involved vertebrae are smooth. There is a paravertebral abscess along the left borders of the first to fourth lumbar vertebrae.



Fig 13 Appearance of typhoid spine twenty and one-half months after the first examination. The first and second lumbar vertebrae are ankylosed by dense bony bridges. Same case as shown in Figures 9 to 12.

At autopsy an abscess cavity measuring 2 cm. in diameter was exposed on the under surface of the manubrium sterni, with extensive necrosis of the bone. Examination of the spine showed a large fluctuating abscess cavity surrounding the left borders of the first to fourth lumbar vertebrae. The sections of the second vertebral body showed extensive caseation, with fibrosis and round-cell infiltration. The bacteriologic examination of the pus from the parasternal and paravertebral abscesses showed numerous tubercle bacilli.

That the roentgenologic appearance of a tuberculous spondylitis may imitate that of a deforming spondylosis is well demonstrated in Figures 5 and 6. These post-mortem films show a slight lipping of the vertebral bodies. The right borders of all

the vertebral bodies, are overbridged by large, irregular spurs which are most marked between the first and second, and second and third. There are numerous larger and smaller spurs on both the left and anterior borders of the lumbar vertebrae. The right sacroiliac joint is completely obliterated. The vertebral bodies are slightly irregular in outline. The bones are not atrophic.

The films taken at two different occasions within the last half-year prior to death showed the lumbar intervertebral spaces to be fairly normal in width. The psoas shadows appeared to be a little fuller than normal, but the appearance was not definite enough to warrant the diagnosis of a psoas abscess. All the roentgenologic findings were in favor of a deforming spondylosis, the main points being the generalized involvement of the entire lumbar column, the large hypertrophic spurs, and the well maintained intervertebral spaces.

At autopsy the prevertebral fascia over the entire lumbar spine was found to be greatly thickened, and the overlying adjacent structures were densely adherent. Incision into the tissue revealed a thin, yellowish-green pus, while the psoas muscles were yellowish-green in color. Incision here revealed numerous small cavities lined by rough, shaggy, irregular walls. All the intervertebral discs of the lumbar spine were eroded and replaced by a greenish, thick fluid, smears of which exhibited numerous acid-fast bacilli and other organisms. The lateral view of a section of the removed lumbar vertebra (Fig 6) shows very beautifully the destruction of the discs, which could not be recognized on the original films. It also shows the irregular contours of the vertebral bodies. The bone trabeculae throughout the arches and bodies are rearranged, some of them are thinned, others are surrounded by smaller and larger areas of new bone productive patches, giving the mottled appearance.

The above three cases showed unusual manifestations of tuberculous spondylitis. They presented one common feature—that

and finally the two vertebræ unite. At times, in the early stage of the disease, irregularities of the vertebral bodies are demonstrable, while changes in the vertebral bodies seldom are. Periosteal new bone production is common.

We have had the opportunity of observing two cases of typhoid spondylitis.

J. B., aged 35 years, white, male, was admitted to Cleveland City Hospital with typhoid fever. The Widal reaction was positive and typhoid bacilli were cultured from the blood. Blood Wassermann was negative. For 22 days the patient ran a septic fever averaging between 39° and 40° C., and then the temperature curve gradually came down to normal. He was discharged, improved, on the seventy-fourth hospital day.

On the one hundred forty-fifth day after the onset of illness he was readmitted, complaining of severe pain in the lumbar region, of four weeks' duration. The pain had become gradually worse, making it impossible for him to twist or move. On physical examination there was found to be slight tenderness over the lumbar spine, no rigidity of the muscles. Most of the pain was elicited by the patient moving in bed. His temperature varied between 37° and 38° during the first four weeks of his stay in the hospital. Roentgen studies of the spine at this time showed a marked left scoliosis of the entire lumbar arch. The neighboring surfaces of the first and second lumbar vertebræ were moth-eaten in appearance and the disc between them was narrowed (Figs 9 and 10). The patient was placed in a body cast at this time and his pain became less severe.

A checkup examination 39 days later showed a remarkable change. The scoliosis disappeared and the narrowing of the disc became more marked. There were large, irregular bony spurs around the neighboring borders of the first and second lumbar vertebræ, which overbridged the intervertebral space (Figs 11 and 12). No bone atrophy was noted. At subsequent examinations the outlines of the neighboring surfaces became more clear-cut, and

the hypertrophic spurs more dense and more sharply defined. The pain gradually decreased and the patient was discharged symptomless two months later.



Fig 15 Typhoid spondylitis showing ankylosis between the second and third lumbar vertebræ by large bony spurs. There is a paravertebral abscess on the left, displacing the left kidney laterally.

The last examination, 15 months later, showed a marked narrowing of the disc, a slight osteosclerosis of the neighboring surfaces of the involved vertebra, and powerful bony spurs, producing an ankylosis between the two vertebræ (Figs 13 and 14). The patient was symptom-free.

C. G., white female, 48 years of age, about six weeks before admission experienced a sudden pain in the left side of the back, which radiated downward to the perineum and to the inner side of the thigh. The pain was so severe that it kept the patient awake at night. There had been occasional vomiting during the previous two weeks.

On physical examination a firm mass about the size of a small grapefruit, which did not descend with inspiration, was palpated in the left upper quadrant. The

collapse of the vertebral body, with well maintained intervertebral discs

Figure 7 shows an unusual behavior of the disc. The film was taken at 2 hours after the injection of lipiodol into the cisterna magna and shows a complete stoppage of the contrast material at the level of the upper border of the fifth dorsal vertebra. The lower half of the sixth dorsal vertebra and the upper surface of the seventh are markedly destroyed, and the intervertebral space between these two vertebrae is obliterated so that the destroyed surfaces of the two neighboring vertebrae impinge on each other. There is a kyphosis at this level. The roentgenologic appearance of this case was not unlike a tuberculous spondylitis. All the vertebrae were atrophic, and there was no evidence of regenerative changes. There was a kyphosis at the site of the lesion and an absence of the shadow of the disc. Without a clinical history of the previous removal of a malignant thyroid, the diagnosis of a metastatic tumor could not have been made roentgenologically. At subsequent autopsy, metastatic tumors of the sixth and seventh dorsal vertebrae, with involvement of the spinal cord and herniation of the disc into the vertebral bodies, were found, secondary to an adenocarcinoma of the thyroid.

Wagoner and Pendergrass (38), in a recent publication, also pointed out that "fractures, metastatic processes, and tuberculous caries of the vertebrae may at some stage of the disease simulate each other" and that "the intervertebral disc may disappear in metastatic tumors, probably due to herniation into the body of the vertebra at the weakened point near the seat of metastasis."

Figure 8 demonstrates herniations of the discs and subsequent narrowing of the intervertebral spaces between the eighth and ninth, ninth and tenth dorsal vertebrae, between the first and second, and second and third lumbar vertebrae into the vertebral bodies, in a case of widely generalized osteolytic metastatic tumors, secondary to a carcinoma of the right breast.

## TYPHOID SPINE

Spondylitis typhosa is always a disease of the convalescent stage of typhoid fever. It occurs principally in adults, between the ages of 15 and 35, though in rare instances it has been observed in children and older individuals. Men are more subject to this disease than women, the ratio being 85:15 per cent. It seldom occurs before the seventh week after the onset of illness, there usually being a symptomless interval between the typhoid fever and the onset of the spinal symptoms, amounting to from three to eight weeks. However, there are cases reported in which this interval was from three to eight months. In Puhl's (27) case the typhoid spondylitis developed ten years after the typhoid fever. Such cases, however, are rare.

The disease usually begins with indefinite, slight pain that rapidly increases in intensity and may become agonizing. In such cases the slightest motion aggravates the pain and turning becomes almost unbearable. Some cases, however, are mild and may escape detection. According to various statistics, typhoid spondylitis occurs in between 0.18 and 2.7 of all cases of typhoid fever. The course of the disease, according to Puhl (27), is variable, but seldom fatal, consequently the pathologic data are scant. Fraenkel (12) was able to demonstrate typhoid bacilli in the vertebrae of his autopsied case.

The disease has two forms: (1) the spondylitic and (2) the perspondylitic. In the first form, which is rare, necrotic areas occur in the vertebrae and transverse processes. The vertebral body may collapse. In the second form, the involvement is mainly localized in the periosteum and disc. This form represents the most common manifestation of typhoid spondylitis.

According to Krause (19), during the first stage of the disease the roentgenologic findings are negative, but from three to six weeks later changes of the intervertebral spaces are demonstrable. They become more opaque, their width diminishes,

However, Schmorl (29) published a case of typhoid spondylitis in which the disease was represented by such marked destruction of the tenth dorsal vertebral body that the body collapsed and only the upper and lower end-plates remained intact. The intervertebral discs above and below the destroyed vertebra were of normal width, and the end-plates of the diseased vertebra were smooth.

#### INFECTIOUS SPONDYLITIDES

In infectious spondylitides caused by syphilis, strepto- or staphylococci, influenza bacilli, pneumococci, etc., the behavior of the disc is also variable. In certain cases the process involves the end-plates and the intervertebral discs, in others, it is more localized in the bone. In most of the cases a considerable amount of new bone forms. In the more virulent instances osteolysis is predominant.

The following cases demonstrate that the disc may or may not be destroyed in osteomyelitic spondylitides also.

C. F., white male, aged 23, was admitted to the Cleveland City Hospital with a swelling in the left lumbar region of 15 months' duration. The patient had had an osteomyelitis of the left tibia ten years before, followed by an osteomyelitis of the left humerus.

On examination, a fluctuant area of swelling and redness was found in the right lumbar region, extending from the posterior axillary line to the spine and measuring five to six inches in length. On the day of admission the abscess was incised and about three ounces of thick pus obtained, culture from which showed non-hemolytic streptococci. Acid-fast stains showed no evidence of tubercle bacilli.

Roentgenograms taken on admission showed the seventh and eighth dorsal vertebrae to be completely fused, with no evidence of spur formation. The vertebral end of the eighth right rib, however, showed a marked osteosclerosis (Figs 16 and 17). The intervertebral space between the tenth and eleventh dorsal ver-

tebrae was markedly narrowed, while the tenth vertebra was deformed, there being a defect on its anterior surface and the body being slightly wedge-shaped. The



Fig 17 Lateral view of the same case as shown in Figure 16, showing the marked narrowing of the intervertebral space between the tenth and eleventh dorsal vertebrae, with bone destruction around the anterior part of the body of the tenth dorsal.

anterior border of the eleventh dorsal also showed some irregularity. There were large hyperostotic spurs between the borders of the eleventh and twelfth dorsals and between the twelfth dorsal and the first vertebra of the lumbar spine, and a slight gibbus between the tenth and eleventh dorsal vertebrae, which findings confirmed the clinical diagnosis of osteomyelitis of these vertebrae. From a roentgenologic standpoint the differentiation between a tuberculous and an infectious spondylitis could not have been made, though the diagnosis was established with the aid of the clinical history and the laboratory findings.



temperature ranged between  $37.5^{\circ}$  and  $38.8^{\circ}$ . On admission, the red blood count was 4,340,000, the white blood count



Fig 16 Osteomyelitis of spine showing complete fusion of the seventh and eighth dorsal vertebrae due to destruction of the disc and marked narrowing of the intervertebral space between the tenth and eleventh dorsal vertebrae, with marked spur formation between the borders of the eleventh and twelfth dorsals

21,800, and blood smear showed 84 per cent polymorphonuclears. The urine contained albumin and three + sugar.

A film of the abdomen taken on admission showed the second and third lumbar vertebrae to be united by dense bony spurs, with an almost complete disappearance of the disc. The left kidney appeared to be displaced to the left by a mass situated near the left borders of the second and fourth lumbar vertebrae (Fig 15). The shadow of this mass merged with the

shadow of the kidney. Subsequent pyelograms showed a fairly shallow defect on the inner upper surface of the left kidney. The findings were thought to be due to either a kidney tumor originating in the cortical substance of the inner and upper part of the left kidney, or to an extrinsic tumor, causing a pressure defect. The lesion of the spine was diagnosed as an old infectious spondylitis. Little attention was paid to it roentgenologically or clinically, because the overbridging was so dense that the appearance suggested an old process.

At operation, the abdominal mass was exposed, a small incision being made through the peritoneum into it, following which a large quantity of thick, green pus was evacuated. Two rubber drains were inserted and the abdomen quickly closed. The patient died the day following the operation. The culture from the pus yielded colonies of typhoid bacilli.

Apparently this patient had an ambulatory typhoid fever some time before her present illness started, her condition being caused by a typhoid spondylitis and a paravertebral abscess. At that time we did not realize how rapidly new bone productive changes could occur in typhoid fever and neglected to pay sufficient attention to the spinal lesion. The previous case, however, taught us that in this disease large spurs may form during a few weeks' time. The patient had not given a history of a preceding illness and, due to her death, we were unable to check the clinical history. The roentgenologic appearance of both our cases is in accord with the majority of published cases (Krause, 19, Margulis, 24, Van Eden, 37, Lyon, 23, and others) in which, according to the summary of Lyon, "a narrowing of the intervertebral disc, participation of the end-plates of the neighboring vertebrae, without evidence of a deeper bony lesion, periosteal bone production, and rapid regression of the inflammatory and destructive changes" occur. The narrowed disc and the bony bridges remain as signs of the previous disease.

rarely and the outlines of the vertebral body become irregular. The roentgenologic differentiation between tuberculous and osteomyelitic spondylitis is often impossible.

### CONCLUSIONS

Wagoner and Pendergrass (38), Ellmer (11), and Freund (13) have published statements which appear to be confirmed by our investigations. The changes of the intervertebral disc can be evaluated only as an index of a vertebral lesion. Due to the close relationship of the vertebra and disc, not only tuberculosis, but the great majority of infectious spondylitides may extend into the disc during some stage of the disease. A primary infection of the disc is possible in younger individuals without involvement of the vertebral body, producing a marked narrowing or a complete obliteration of the intervertebral space on the roentgenogram. Schmorl demonstrated that herniation of the disc may occur in cases of fracture of the vertebral body, and that narrowing of the disc may also be present. As the fracture heals, periosteal callus develops and, because of the narrowed disc, the roentgenologic differentiation between an old trauma and an old infectious arthritis becomes extremely difficult in some cases.

Although in the great majority of instances the disc is definitely narrowed on the roentgenogram in tuberculous spondylitis, cases are known in which the width of the disc was not changed and in one of our cases was even wider than normal. Paravertebral abscesses occur most commonly in tuberculous spondylitis, but have been found also on numerous occasions around osteomyelitic processes and in one of our cases in the neighborhood of a typhoid spine.

Sgalitzer in his publication (31), to which there is a very general reference in the world literature, is inclined to suspect tuberculosis whenever there is a change in the physiologic curve of some vertebral segment. He pays too much attention to

the narrowing of the disc as an important sign of the spondylitis. Two of his illustrations (Figs 6-A and 6-B) show a diminished width of the seventh and eighth



Fig 19 Unusual appearance of an osteomyelitic process of the first lumbar vertebra, showing the destructive process to be situated on the surfaces of the epiphyseal rings facing the vertebral body. The epiphyseal rings are elevated. The intervertebral spaces are of normal width. The normal epiphyseal rings above and below the involved vertebrae are well visualized.

dorsal vertebrae, with a narrowing of the disc between them, in a 46-year-old man, but the illustrations also show typical Schmorl's nodes on the lower borders of the seventh and eighth dorsal vertebrae and a small calcified patch in the ninth intervertebral disc. This appearance is quite characteristic of cartilage herniation rather than of tuberculosis. Despite the thoroughness and excellency of this publication, we feel that Sgalitzer was too dogmatic in his roentgenologic diagnosis of tuberculous spondylitis.

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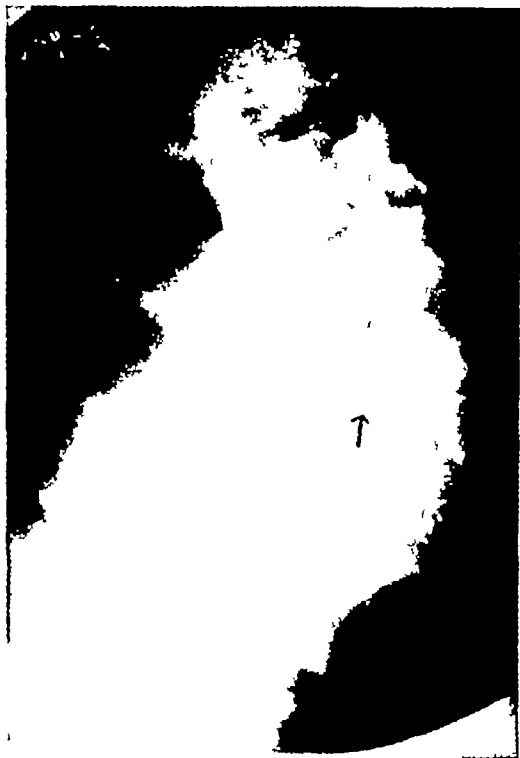


Fig 18 Osteomyelitis of the spine showing destruction of the neighboring surfaces of the fifth lumbar and first sacral vertebra, with a complete disappearance of the disc and spondylolisthesis formation

sacrum and lower part of the fifth lumbar vertebra, in a pathologically proven case. The lateral view shows a slight destruction of the lower surface of the fifth lumbar vertebra and the upper surface of the sacrum. The fifth intervertebral disc is destroyed and, due to a destructive process throughout the small joints between the sacrum and fifth lumbar vertebra, a spondylolisthesis developed (Fig 18). At post-mortem examination the lesion was found to be surrounded by a large retroperitoneal abscess, the pus of which contained streptococci as did the culture from the blood. This case will be reported in detail by Dr Harbin.

Figure 19 shows the unusual appearance of an osteomyelitic process of the first lumbar vertebra, involving the epiphyseal rings but not the discs, which was metastatic in origin. The patient was a 14-year-old white female who died as the consequence of an acute vegetative endocarditis of the mitral leaflets and staphylococcus septicemia. At autopsy a fusiform collection of liquid yellow pus was found in the region of the first lumbar vertebra, the periosteum over the anterior surface of the first vertebra was elevated by an extension of the abscess and the bone underneath it was slightly irregular and roughened. Sections of the bone and smears of the pus did not reveal the presence of tubercle bacilli. A roentgenogram of the specimen showed a slight bone destruction on the anterior surface of the first vertebra of the lumbar spine. The upper and lower epiphyseal rings of this vertebra were elevated and their surfaces facing the vertebral body showed a slight irregularity. The intervertebral disc above and below the lesion were well maintained and sharply defined in this case.

Reviewing the literature one can find that osteomyelitis of the vertebrae is often diagnosed as tuberculous spondylitis. Kastner (16) reports a case in which, during the course of the disease, different roentgen examinations showed a typical appearance of tuberculous spondylitis. Only in a later stage of the disease was the correct diagnosis made, when bony bridges and areas of condensation developed. LeFort and Ingebraus' (20) case also showed the roentgenologic appearance of a Pott's disease, but the bacteriologic examination of the blood yielded *Staphylococcus aureus*. Their second case also showed all the roentgenologic symptoms as of tuberculous spondylitis. Fraenkel's (12) second and third cases showed complete destruction of the disc in osteomyelitis imitating tuberculous spondylitis. Borchers (7), in his discussion of osteomyelitis of the spine, states that roentgenologic diagnosis of this lesion during the first two weeks of the disease is impossible. In later stages the trabeculae

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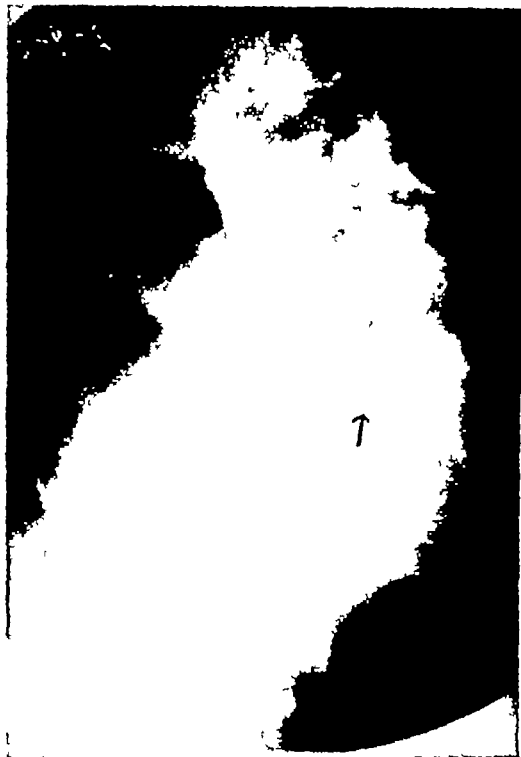


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In a vertebral lesion, be it due to tuberculosis, pyogenic infection, or localized metastatic tumor, the roentgenologic appearance is possibly of greater importance than any other single clinical factor, as it enables the clinician clearly to visualize the location, extent, and progress of the lesion. There are certain generalized arthritic processes like spondylosis deformans (hypertrophic arthritis) and spondylarthritis ankylopoietica (Strumpell-Marie's disease) in which the roentgenologic appearance is clear-cut. Primary benign and malignant tumors and generalized metastatic tumors of the vertebrae can be diagnosed with great accuracy, as well as recent fractures, congenital anomalies, and some of the diseases described recently by Scheuermann and Schmorl, but the differential diagnosis between certain old vertebral fractures, chronic tuberculous spondylitis, and chronic infectious spondylitis on the one hand, and localized metastatic tumor and acute tuberculous or infectious spondylitis on the other hand, is often difficult and cannot be made with certainty. Repeated examinations are of great value in the differential diagnosis between a tuberculous and an infectious spondylitis (for in the latter disease new bone formation occurs in relatively early stages of the disease), but may fail one in the differential diagnosis between localized metastatic tumor and acute tuberculous spondylitis.

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can, however, usually be dispensed with, as the data it furnishes do not differ in character from those found in a good single film "

Despite such authority for the value of the single film, there remains, among the greater number of radiologists, a firmly fixed conviction that stereoscopy is essential in chest diagnosis. This is less true in Europe, where single or multiple flat films are commonly used, but in this country, stereoscopic films are made routinely in almost every institution in which chest work is done, even in places where no plate changer is available and the two plates cannot possibly be made without intervening motion on the part of the patient. That such films can have no value in the accurate production of a three-dimensional image seems never to occur to those performing the examination.

In office practice, the situation is entirely different from that in institutional work, or in routine examination of groups such as school children, university students, tuberculosis contacts, and in insurance or military physical examinations. For instance, the overhead and the cost of the trained opinion of the practising radiologist are the major factors in determining charges, and this is true to such an extent that the cost of an extra film in a chest examination is scarcely to be considered. Moreover, since in office practice the bulk of the patients are persons in whom there is some cogent reason to suspect pathology, it would be a most shortsighted policy and would risk one's reputation as a diagnostician to save one film, or even three or four, on an examination. Granting all this, however, there is grave doubt in our minds whether the routine use of stereoscopic films is the most advantageous way of using an extra film in chest diagnosis. Certainly, there are many cases in which lateral or oblique films, or one light film and one dark film, or an antero-posterior and a postero-anterior film, or lateral decubitus films for fluid, or special films of the apices, give far more information than stereoscopic films can possibly

do. Each case must be considered on its own merits, and, in case of doubt, a flat film will give as much information as a stereoscopic pair in determining the best procedure for further examination.

On what, then, does the value of stereoscopic examination depend? We believe all will agree that the following three factors constitute its chief value as contrasted with the flat plate:

- 1 The ability to recognize at a glance three-dimensional relationships

- 2 The ability to recognize as artefacts certain shadows which may be seen in one film and not in the other

- 3 The relative change in the position of various shadows which permits images obscured in one plate to be seen in the other

Of these three factors, the first is the only one which requires the use of the stereoscope, since it goes without saying that no shadow can be discerned in the stereoscope which does not appear on at least one of the films constituting the pair. It must also be remembered that *unless a particular shadow appears on both of the plates with sufficient distinctness for corresponding points within it to be readily identified*, any judgment of the depth of the shadow can be only a subjective illusion, with no valid basis in the physics or optics involved.

Thus, the value of the three-dimensional image is open to question, and it is a matter of daily experience that even expert radiologists will differ in judgment as to the position of the same shadow on the same pair of plates. Measurement of the shift of corresponding points in the two plates relative to other known points, is, in reality, a more reliable, although somewhat more cumbersome, method of estimating three-dimensional relationships. However, even this method becomes unreliable if the slightest movement is allowed to occur between the exposure of the two films. Even a slight respiratory movement between exposures can cause lung markings to appear anterior to the anterior ribs,



## THE RELATIVE VALUE OF STEREOSCOPIC AND SINGLE FILMS IN THE ROUTINE EXAMINATION OF THE CHEST<sup>1</sup>

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IT is becoming increasingly clear that the only real hope of materially diminishing the present incidence of tuberculosis lies in an earlier diagnosis than is possible by awaiting suspicious symptoms, or even by a physical examination. Such a diagnosis can be obtained only by systematic roentgen examination of large numbers of apparently healthy individuals.

Certainly, all known contacts of every active case of tuberculosis should have roentgen examination, but this is not sufficient, as many patients spread the infection for months or years before their condition is diagnosed. Extensive surveys of large groups by the roentgen method are becoming, therefore, more and more frequent. Such surveys have almost invariably detected enough unsuspected cases to more than justify the expense involved. Nevertheless, they are expensive, and in many cases impossible on that account alone. In such a survey, the cost of films and chemicals is a major item, so, if a single film can be substituted for the stereoscopic pair, the cost can be reduced materially. This may permit such surveys to be made in many groups in which it would be otherwise impossible. As a matter of fact, many of the tuberculosis surveys which have been made, notably those by Chadwick and Zocks (1), and by the University of Minnesota Health Service, were done with the single film. Some criticism has been directed at these on this account.

There is a wide difference of opinion among roentgenologists regarding the necessity of stereoscopic films for chest examination. The stereoscopic method for chest

examination is said to have been originated by Wenckebach. A demonstration by Lenhardt and Kiessling, at the first Roentgen Congress in 1905, attracted wide attention. It was not, however, until later that much precise knowledge of pulmonary shadows in terms of pathology began to accumulate. The x-ray generators available during this period were not sufficiently powerful to produce plates possessing fine detail, consequently, the stereoscopic method was of great assistance in recognizing and evaluating any changes present. Gradually, the stereoscope came to be considered indispensable. Dunham (2), in 1918, said, "The single plate adds practically nothing to the fluoroscope," and again, "The stereoroentgenogram is essential to the complete roentgen examination of the chest." However, as *technic and apparatus have improved*, and the flat plate has shown greater and greater detail, these ideas have become of doubtful validity, and many excellent radiologists disagree or agree only with reservations.

Forssell (3) was of the opinion that a good single film, carefully studied, provided as much information as a stereoscopic set. Holmes and Ruggles (4) say, "It is not necessary to take stereoscopic films as a routine procedure, but, in selected cases, they may be of considerable value." Sante (5) says, "While stereoscopic examination is especially helpful in cases requiring critical examination of the fine lung structure, it is not, in our opinion, essential in all cases. One can acquire great skill in the interpretation of flat films of the chest." Wessler and Jaches (6) considered a good flat film superior to a mediocre stereoscopic set, while the U. S. Army Manual (7) says, "Stereoscopy

<sup>1</sup> Presented before the Minnesota Radiological Society, Feb. 13, 1932.

TABLE I

		Single Film Examination			
		Considered pathologic	Considered doubtful	Considered normal	Total
Combined examination	Pathologic	360	9	0	369
	Normal	13	32	86	131
	Total	373	41	86	500

methods was taken as the criterion of correctness in the examination

Because the proportion of incipient to moderately or far advanced cases in this material is probably smaller than in the usual large tuberculosis survey, an attempt was made to offset this factor in the following manner. For each film or stereoscopic pair a detailed description of the pathology was recorded, covering the nature of the lesion or lesions and their extent. Each area of pathology was then considered separately in such a manner that, if any one area was recorded as normal when pathologic, or pathologic when normal, it was considered that that film was incorrectly diagnosed, regardless of how many other areas on the same film had been correctly recorded. The results of the study are listed in Table I.

It will be noted that in no case was a patient diagnosed as normal on the basis of the single film who later was found to show pathology on the combined examination. Thirteen cases thought to be abnormal on the single film proved to be normal on the combined examination, while 41 cases were considered doubtful on the single-film examination.

In attempting to evaluate the significance of this figure, we consulted Dr A E Treloar, Assistant Professor of Biometry at the University of Minnesota. By assuming that the bivariate distribution conforms reasonably with the normal surface, it is possible to calculate the correlation coefficient,  $r$ , by the tetrachoric method. This turns out to be 0.98, a very high correlation, both when the doubtful cases are grouped with the normals, and when they are divided between pathologic and normal in the ratio of total

pathologic (369), to total normal (131). If the doubtful cases are grouped with the pathologic cases, the correlation is still higher. Accepting 0.98 as the correct coefficient, the "expected frequency" in this cell of the table turns out to be 1.6 per 500 cases rather than 0, the observed value. This is in reasonable accord with the observed value. Moreover, when  $r$  is calculated by the "equivalent probability method," which is independent of normality of distribution, it appears that  $r$  is greater than 0.95, the highest correlation to which the method is suited. This would suggest that the assumption of distributional normality is justified.

Accepting, therefore, 1.6 as the expected number of lesions which will be overlooked by the single-film examination of 500 cases, it appears that the error in this respect will amount to 0.3 per cent of the total, or to 0.4 per cent of the pathologic cases. As the proportion of pathologic cases is far higher in this material than in the usual tuberculosis survey, the latter figure, *0.4 per cent of the pathologic cases*, seems a more appropriate basis of calculation.

From this, it is reasonably clear that the number of tuberculous patients missed by flat-film examination will be insignificant, but it remains to be demonstrated that enough re-examinations will not be required to offset the saving effected by their use. This is impossible to determine without knowing how many early cases will be found in the particular survey under consideration. We do not believe that any patient should be diagnosed as tuberculous on the basis of a single film unless the pathology is so obvious as to be unmistakable. Since, however, the purpose of the examination is to locate these particular cases

and the authors have seen tuberculous cavities which appeared to occupy the same position. In many cases, the distortion is so obvious that it is readily discounted but more often it is not. Even the absence of respiratory movement does not insure a true stereoscopic effect because, as has been shown, even in plates exposed for one-twentieth of a second there is often motion due to the heart, and, while probably not a very serious factor, it does cause distortion in the parts adjacent to the heart.

It follows, therefore, except in unusual cases, that no information is made available by the use of the stereoscope which may not also be obtained by the comparison of the same two plates side by side in the viewing box. This method has been employed to a large extent by one of us for many years. This again raises the interesting question of whether it would not be better, as a routine procedure, to substitute for the usual stereoscopic pair one made in the same way but with different exposures—a method which was long ago suggested but has never been widely adopted (8). These could be read side by side in the viewing box. The shift would provide the second and third advantages of stereoscopic films, as listed above, and it is well known that certain types of lesion show up best in a thin and others in a dense film. This problem is, however, outside the scope of the present discussion.

Waring (9), in 1924, took considerable pains to demonstrate that, in the adult, 48.4 per cent of the lung-fields are covered by one rib shadow and 20.77 per cent by two rib shadows, on the assumption that an early lesion which can be distinguished through the rib shadow will be burned up if in a free area, while one visible in a free area will be obscured by an overlying rib. Experience has shown that this assumption is not valid unless the contrast gradient of the film is too steep as the result of too high voltage. In a good film, even a minimal lesion will rarely be completely obscured by rib shadows, and

then only in the rare case in which no part of the lesion overlaps the free areas or areas covered by single rib shadows.

It has been our impression for some time that the technical factors have been sufficiently perfected that rarely, if ever, will any lesion be completely obscured on any good single film. Should this impression prove correct, it would follow that little or no pathology would be missed on the single film, and that any mistakes which did occur would be, rather, in the nature of interpretation of the presence of lesions that did not exist. In such a case, the real value of the stereoscope would lie in helping to evaluate shadows of questionable significance observed on a previous single-film examination. Included among these will be such artefacts as may simulate abnormal shadows.

In the routine examination of large groups of persons, a real saving could, therefore, be effected with no loss in efficiency if the following points could be definitely established:

- (1) That no pathology will be overlooked which would have been picked up on stereoscopic examination,
- (2) That the total number of cases requiring re-examination to evaluate doubtful shadows, will not be large enough to offset the savings on the original examination.

As a test of the above points, we determined to compare the diagnosis of stereoscopic films with the diagnosis of a single film taken from the same pair. Five hundred such pairs were taken from our files in consecutive groups of from fifty to one hundred, and one film from each pair was selected at random from which to record a careful and detailed diagnosis. Later, each pair was examined with the stereoscope and a second diagnosis was recorded. Then, the two independent diagnoses were compared with each other and the discrepancies were checked with a third examination of the films, both as stereoscoped and as two flat plates. The third combined examination by the two

# A CASE OF RIGHT-SIDED ATYPICAL DIAPHRAGMATIC HERNIA

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**D**IAPHRAGMATIC hernia as a clinical entity has of recent years become so common a finding that it would be superfluous to report a single case unless there were something unusual in regard to anatomy, diagnosis, or treatment

Diaphragmatic hernias are divided by most observers into two main types traumatic and non-traumatic The non-traumatic type is practically always congenital These two types are cross-divided into so-called "true hernias," or those in which there is a hernial sac, and those without a sac, so-called "false hernias" Either type may be congenital or acquired While we have said that non-traumatic hernias are nearly always congenital, we mean that, as in the case of other herniations from the abdominal cavity, there is a muscular weakness or deficiency which predisposes to the development of hernias later in life, if it is not already partially present at birth

If the herniation is present at birth, it is due to embryologic deficiency, usually without an enclosing sac The most common sites of such herniations are (1) through the esophageal opening, (2) through the foramen of Bochdaleck (hiatuspleuro peritoneals), (3) through the dome of the diaphragm, (4) through the foramen Morgagni, (5) through the congenital absence of the left half of the diaphragm Hernias which are non-traumatic and acquired following birth, but which may be included in the congenital group because of the congenital predisposition, take place usually at the same sites If acquired after birth, the hernia as a rule has an enclosing sac Traumatic types as a rule arise as a result of a crushing injury or puncture wound and usually herniate either through the esophageal

opening or the posterior portion of the left side of the diaphragm If along the esophagus, there is usually a sac, and if through the leaf of the diaphragm there is usually no sac Of course, if there is direct injury to the diaphragm itself, the hernia may occur at any point All of this information in regard to herniations of the diaphragm is already well established Most of them, whether traumatic or non-traumatic, whether congenital or acquired, occur on the left side of the diaphragm in subjects who are cardiosinistra, since close apposition of the liver to the diaphragm usually prevents herniations on the right side Greenwald and Steiner (15) state that the proportion is about 77 per cent on the left side and 20 per cent on the right, with about 2.5 per cent occurring on both sides

We have looked through the literature of recent years and are unable to find a case corresponding to the one about to be discussed In this case, herniation took place on the right side of the diaphragm posteriorly, behind the outer crus through the mesial lumbocostal arch, it was the distal end of the stomach, pyloric valve, and some six inches of the duodenum which were herniated The fundus of the stomach and cardiac orifice remained in the abdomen underneath the left dome of the diaphragm There was a well-defined ring in the diaphragm about the herniated organ, and the viscera that were herniated were covered by a sac, indicating that this herniation took place after birth (Fig 1)

*Case History* —The patient was a colored girl, 17 years of age, who entered the hospital on Friday evening with a diagnosis of ptomaine poisoning following the eating of sandwiches on the preceding Tuesday She appeared emaciated and exhibited

for purposes of further study, it seems permissible to dismiss all such re-examinations from consideration unless they fail to substantiate the original diagnosis. In our material there were 13 such cases, which, with the 41 cases showing doubtful areas, makes a total of 54 in which re-examination would have been required on this basis. Of the 41 doubtful cases, there were 11 which, in addition to the doubtful area, contained other areas of obvious pathology. These would not have been re-examined in the ordinary course of events. Including the entire 54, however, there would be left only 11 per cent requiring re-examination. This is, at best, only an indication of what may be expected, and it must be determined in each individual survey whether or not the number of re-examinations is likely to offset or more than offset the saving. In many surveys, the percentage of entirely normal cases may be as high as 95 per cent.

In a study of this type it is impossible to eliminate the personal equation, and certain variations must be expected according to the ability of the individual to interpret more correctly with or without the stereoscope. Either type of interpretation will be reliable only in the hands of a trained roentgenologist, and we cannot emphasize strongly enough that there is no magic about the stereoscope. It will not permit any save an experienced roentgenologist to make dependable diagnoses in other than the most obvious lung con-

ditions. In fact, the stereoscopic method probably requires more, rather than less, skill in interpretation to avoid error.

#### CONCLUSIONS

1 Rarely will a single chest film of good quality, and carefully studied by a trained roentgenologist, fail to show any lesion which would have been demonstrated by a stereoscopic pair.

2 The expected value for such failure, as shown by this study of 500 cases, is 0.4 per cent of the pathologic cases.

3 In routine tuberculosis surveys a considerable saving can be effected without significant loss of efficiency by the use of the single film, unless the particular material involved requires enough re-examinations to offset the savings.

4 In office practice, on the other hand, some type of multiple-film examination is much to be preferred.

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of the stomach was herniated through the right side of the diaphragm into the chest, taking with it six inches of the duodenum (Figs 4 and 5)

The cause of the patient's suffering was now quite apparent. She had a high small intestinal obstruction due to incarceration of the duodenum where it passed through the hiatus in the diaphragm. As above mentioned, the abdomen was scaphoid, the intestines were practically devoid of gas. Since the patient had been more or less obstructed for some five days, an emergency operation was resorted to, performed by Dr O K Parry.

*Operation*—A high right rectus incision was made. The left lobe of the liver was lifted and the abdominal side of the hernia examined. Traction on the stomach or duodenum was of no avail, so the ring was incised in the posterior lateral direction. Traction again failing to reduce the hernia, a hand was inserted into the hernial sac, adhesions of the stomach released, and the stomach and duodenum drawn down into the abdomen. Interrupted sutures then repaired the incision in the diaphragm and closed the aperture. The stomach and duodenum showed subserous hemorrhagic changes at the site of constriction and considerable inflammation of the portion which had been incarcerated and partially strangulated. The distal half of the stomach and proximal six inches of the duodenum were contained in a large sac occupying the lower inner portion of the right pleural cavity and passing under the medial lumbocostal arch on the right side. The stomach was attached to the top and diaphragmatic surface of the sac by many fine adhesions. The opening in the diaphragm was about one inch in diameter. A portion of the duodenum and stomach in the thorax were considerably distended with gas and liquid.

Although the patient was given all the usual post-operative treatment indicated in an emergency of this kind, she was in no physical condition after five days of intestinal obstruction to withstand the post-

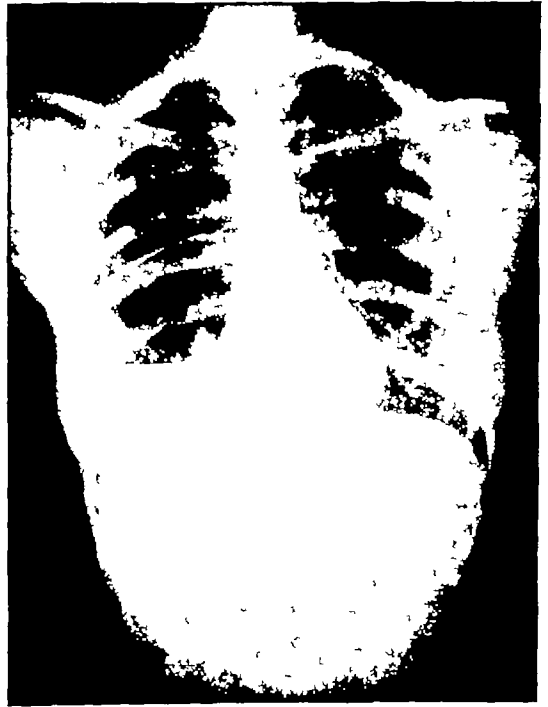


Fig 2 Patient in upright position

operative shock, and died some five hours after the operation.

*Autopsy Report*—The body is that of a 17-year-old, slender, colored female, under-nourished. Skin and tissues very dry. Operative wound in the upper right quadrant.

On opening the chest a glistening white sphere about six inches in diameter was seen to occupy the inner lower portion of the right pleural cavity, it collapsed when the herniated opening was released from the abdominal side. When this hernial sac was peeled from the lung to which it was adherent, one could not determine grossly where the peritoneum and pleura separated, the sac itself apparently comprising the sole covering of the lung over the area to which it adhered.

On opening the abdomen the tissues were found to be very dry. The stomach in its distal portion and the proximal six inches of the duodenum showed subserous hemorrhage, most marked at the point of constriction, and the blood vessels in this portion which had been incarcerated

pernicious vomiting Prior to the onset of this attack the history was entirely negative for any gastro-intestinal complaints

*Physical Examination*—Patient was a slender, apparently under-nourished

than the diaphragmatic level (Figs 2 and 3) The diaphragm itself could be seen some two inches lower The lung-fields about the dome-like viscus were perfectly normal as were the chest findings on the left side For this reason a tentative

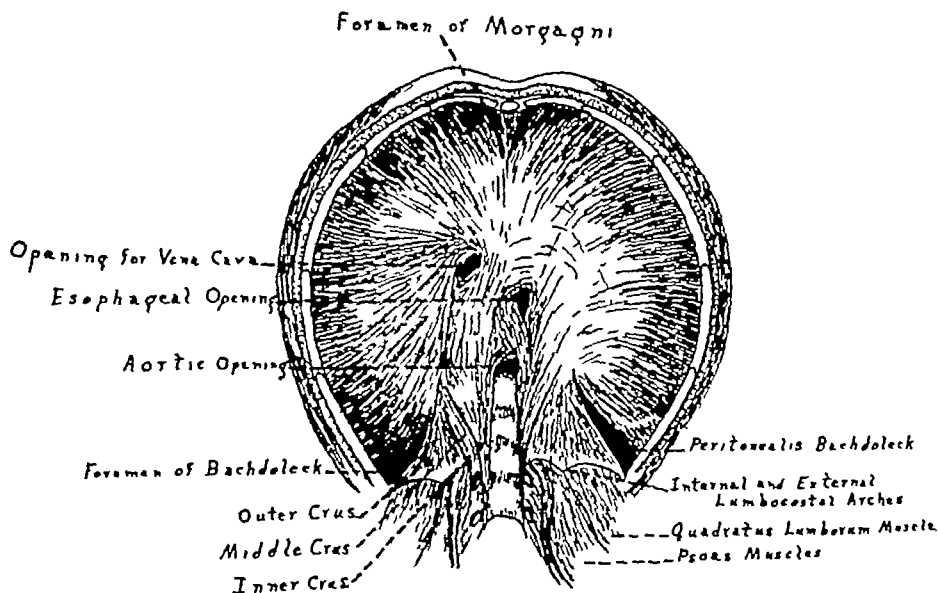


Fig 1

colored girl with a scaphoid abdomen, running no temperature Percussion and auscultation sounds in the left chest were normal In the right chest there was resonance anteriorly and superiorly, and dullness verging on flatness posteriorly Auscultation revealed free fluid in the chest Splashing could be heard on both sides but most marked on the right

*Clinical Diagnosis*—Hydropneumothorax of the right chest, with a question of possible diaphragmatic hernia The patient was referred to the x-ray department for radiographs of the chest because of the suspected hydropneumothorax

*X-ray Examination*—Radiographs were taken of the chest postero-anteriorly and laterally recumbent At this examination a well-rounded, dome-like viscus was seen in the middle third of the right chest, with air beneath and a fluid level higher

diagnosis of herniation of the stomach through the diaphragm was made This examination was followed by a second one in which the patient was examined fluoroscopically while swallowing a barium meal This meal passed straight down the esophagus and did not enter the viscus in the right chest but entered the abdomen through the normal opening in the diaphragm, the esophagus apparently leading to the bottom of the stomach instead of the usual cardiac orifice The stomach fundus underneath the left diaphragm filled with the barium from the bottom up, elevating a column of supernatant fluid which the patient quickly vomited She was then placed in the supine position and about half of the barium passed from the left side of the upper abdomen into the viscus in the right chest, thus establishing the diagnosis The pyloric half

Even though we are repeating what others have said many times, we wish to emphasize, because of its importance, the necessity of considering the possibility of diaphragmatic hernia in every case in which there is a history of abdominal discomfort or pain, and in which the physical examination reveals signs in the lower part of the chest. Also, in all cases of suspected small intestinal obstruction the possibility of this type of herniation should be considered. In both types of cases, x-ray examination of the chest and gastro-intestinal tract seems to be clearly indicated. A word of caution perhaps should be given in regard to the x-ray diagnosis of this lesion. In cases in which herniation is gross, as was the fact in this particular case, the diagnosis is much easier than when the herniation is small. In such an instance, herniation may be entirely absent with the patient upright or the herniated portion may be obscured by overlying viscera, and unless the patient is examined in all possible positions the herniated viscus may not fill with the opaque medium. Furthermore, as Carman, Fineman, Moore, and Kirklin have pointed out, partial hernia of the stomach, such as was present in this case, when filled with gas and fluid, may closely imitate a hydropneumothorax or an echinococcus cyst, or even gas-filled loops of bowel may resemble bronchiectasis, lung abscess, or pluerisy. It should be noted in this case that the preliminary clinical diagnosis was one of hydropneumothorax.

Recently, Dr. Max Weitzen, in an article entitled "Diaphragmatic Hernia with Severe Anemia," has pointed out that obscure cases of secondary anemia may result in patients with diaphragmatic hernia due to petechial hemorrhages arising in the mucosa of the stomach as a result of partial strangulation. It will be noted in the report of this case that the condition of the gastric mucosa was such as to indicate that petechial hemorrhages might have occurred had the patient lived.



Fig 4 Patient in upright lateral position

#### RESUMÉ

A case of non-traumatic true diaphragmatic herniation of the pyloric half of the stomach into the right thoracic cavity is reported. The patient was a young female (the majority of cases occur in males), without previous history of gastro-intestinal disturbance. Sickness and death were caused by strangulation of the duodenum, which passed into the chest with the herniated stomach.

The importance of early recognition of herniation of the diaphragm is pointed out, since many of these cases develop strangulation. The rarity of this type of herniation is emphasized.



were markedly distended and the surrounding tissues were of a dusky reddish hue. The entire stomach showed distention and vascular congestion. The left lobe of the liver was very dark in color

through the narrow diaphragmatic opening. At operation, the stomach was found to be considerably distended and injected, but the severity of her symptoms was due to the high intestinal obstruction



Fig 3 Patient in lateral recumbent position

and showed small areas of subperitoneal hemorrhage. The hernial aperture had been tightly closed by sutures, the release of which allowed the sac in the thorax to collapse. The rest of the organs of the abdomen were apparently normal, although the entire small intestines were collapsed and empty.

The operative findings and autopsy report both confirm the pre-operative x-ray diagnosis in this case. We have here an unusual type of non-traumatic true hernia which may or may not have been congenital. According to Richards (25), the type with sacculation may or may not be congenital, while according to Harrington (1, 8) the congenital type is usually without a sac, and the type acquired after birth has a sac. The patient gave no history of gastro-intestinal disturbance prior to the acute onset of what was thought to be ptomaine poisoning. Undoubtedly she did have some acute gastric disturbance which caused a distention of the stomach and consequent strangulation

None of the barium given at the initial examination passed through the herniated loop of duodenum. The patient was re-examined just before operation—approximately one and a half hours after the diagnosis was established—and up to this time no barium was found in the intestines below the diaphragm. Right-sided herniations, except for the so-called thoracic stomach of LeWald, are rare, and these, of course, are quite rare themselves. In these cases the esophagus is short and the stomach has never been entirely intra-abdominal. We have been unable to locate any case in which the pyloric end of the stomach, together with a small portion of the small intestine only, was herniated in the right side with the fundus remaining in the left abdomen, although we have noted a case, reported by Bridges and Fawcett (23), in which the pre-pyloric end of the stomach was herniated into the *left* side with the fundus remaining in the abdominal cavity.

# EDITORIAL

LEON J. MENVILLE, M D, *Editor*

HOWARD P. DOUB, M D, *Associate Editor*

## LAY RADIOLOGY MEDICAL AND INDUSTRIAL

Medical radiologists all know the necessity for a thorough medical training as a background for the practice of diagnostic as well as therapeutic roentgenology. It is to be hoped that the whole of the medical profession will come to hold fast to this principle. At present we see, however, a minority of doctors who are not so convinced, but who send patients for radiography to non-medical technicians. A great deal has been written and spoken to advance the twin ideals: (1) that physicians should refer their patients for roentgen diagnosis only to medical radiologists, and, (2) that medical radiologists should deserve this by being, as much as possible, well trained and broad-thinking physicians and not merely narrow technical specialists.

The industrial arts are now seen to be using x-rays and radium more and more in inspection of welds, and the gross and fine structure of materials and finished products. It would seem an obvious parallel to the medical ideal of the first paragraph, that such inspection service can be best given by a broadly trained engineer specializing in radiology. To do intelligent radiography of materials one might need as deep an insight into their structure and use as one needs of anatomy and physiology to do intelligent radiography of man.

It would appear, therefore, that a physician radiologist who, because he has an x-ray machine undertakes to do industrial roentgen inspection, is in somewhat the same position as a lay radiographer making roentgenograms of human patients.

The conclusion is that patients should be referred only to a physician, and materials only to an engineer. By adhering to this principle in the industrial case where it means less work for themselves, physician radiologists may make clearer to themselves and others their honesty in promulgating the principle in its application to patients, where it obviously works in the direction of their own self-interest.

ROBERT R. NEWELL, M D

## "I SERVE"

The closing of another year, and the beginning of a new one would make us all reflect more, were it not that possibly the sum total of our efforts to date seem rather futile and lacking direction. We are afraid of striking a balance for the year, and facing the results.

The years creep by in childhood, but to-day they alarm us by their pace. Our days are passing with hurrying feet and we ask, in despair, "To what end?" Why all this frantic struggle and effort? The essence of our being convinces us that there is something deeply worth while in living, but the facts of our experience somehow tend to make us disappointed.

Possibly, like Barrie, we started out to remake the world, but now, we just pray that the world will kindly leave us in peace. When we left our Alma Mater with diplomas of distinction, did we then feel that life owed it to us to bring further distinction and rewards? There may be something fundamentally weak in our approach to the city of our choice. In these days when values long accepted are being discarded, and the whole world seems upside down, it might be worth our while to re-examine our own foundations, and know whereby we live.

I see in my mind's eye the old royal motto "Ich Dien"—"I Serve." It comes as a challenge to us all. Surely there is something more than merely casting ourselves upon the sea of time and allowing life to drift without direction. Man, so richly gifted, so long adorning, cannot escape the fine endowment of his days. This very motto answers his crying need. To thrust it aside, as betraying sentimentalism, and to be caught up in the pursuit of some by-product of his talent, is to find ultimately nothing but dust and ashes.

The life of the crossing sweeper is more to be envied than that of the man, however richly gifted, who merely accumulates his dues, and, building a wall around his dwelling, shuts off his fellow-man. How pathetic he becomes who judges his success by his bank account, and ends his days by being grateful for a smile from his butler.

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Fig 5 Patient in supine position

details are desired, our readers may inquire of Robert H. Lafferty, M.D., Charlotte Sanatorium, Charlotte, N.C.

## BOOK REVIEWS

MANUEL DE RADIODIAGNOSTIC CLINIQUE (Manual of Clinical X-ray Diagnosis) By R. LEDOUX-LEBARD, Chargé de Cours de Radiologie Clinique à la Faculté de Médecine de Paris, Radiologiste des Hôpitaux. Vol. I, pp. 604, with 605 illustrations, Vol. II, pp. 471, with 538 illustrations. Paris: Masson et Cie, 1933. Price 250 francs, in cloth.

This work is intended to meet the need for a complete and up-to-date text on x-ray diagnosis in the French language for the use of students and practitioners. It is based on the lectures given by M. Ledoux-Lebard as Professor of Clinical Radiology, and on research conducted by him and his students and colleagues. No work on x-ray therapy is included.

The book is in two volumes which consist of eight parts, each one, except the first, being devoted to an anatomical system. A bibliography has been appended to each part and this arrangement is most convenient. The first section deals with the general principles of radiography, but no discussion of the physics of the x-ray is given, since the author feels that this phase has been sufficiently well covered in other texts. There is a clear presentation of the principles underlying the localization of foreign bodies, which is amplified by many good diagrams.

The second section is concerned with bones, joints, and muscles. The usual descriptions of the normal appearance and congenital anomalies are given. The discussion of bone tumors is good, but not very extensive. The other subjects in this section are treated adequately.

The third section, dealing with the head and central nervous system, well covers its subject. The descriptions of the cranium, face, jaws, and teeth are somewhat above the average, while the work on encephalography and myelography is described particularly well.

The fourth part takes up the circulatory apparatus. X-ray examinations of the heart and great vessels in the normal and the pathologic states are well covered and represent one of the best sections of the book. Arteriography and phlebography, which are more recent

additions to methods of x-ray examination, are discussed more fully than is found in the average text, and constitute an outstanding feature of this volume. Good visualization of aneurysms is obtained by injecting the abdominal aorta with opaque material. There is an excellent plate showing the lack of circulation in one kidney due to fibrosis produced by tuberculosis, and normal circulation in the opposite kidney brought out by this same method. There is also an excellent demonstration of the increased vascularity in the region of a sarcoma of the upper part of the radius, followed by the decrease in vascularity after x-radiation. These most unusual plates show remarkably well the information that can be obtained by this examination. This method has not been generally adopted in this country, due perhaps to its attendant risks.

The fifth section of the book, dealing with the respiratory system, is a good dissertation on the normal and its variations. The part on acute infections is well done, as is the part on the chronic non-tuberculous respiratory diseases. Lipiodol study of the bronchial tree is particularly good. The great interest in this subject is entirely natural, since lipiodol was first prepared and used by the French. Pulmonary tuberculosis is adequately and completely discussed. The other subjects in this section are also competently presented.

Volume II maintains the high standard of the first volume. The sixth section is devoted to an extensive discussion of the x-ray diagnosis of the normal and pathologic appearance of the gastro-intestinal tract and its appendages. The entire subject is well covered as to text and the illustrations are particularly good. Every condition that one might meet in practice is thoroughly and competently treated. The chapter on duodenal ulcer is one of the outstanding parts of this entire section.

The seventh section dealing with the urinary tract describes adequately the x-ray diagnosis of both normal and pathologic states. While it is rather brief, nothing important has been omitted.

The last part of this volume concerns the genital system and the application of diagnostic x-ray methods to obstetrics and gynecology. There is a complete dissertation on urethrography, which is amplified by good illustrations. Lipiodol is the opaque medium used, indicating again the diverse uses of this substance.

The progress of the race has ever been achieved by men who were willing to give everything they had to an ideal. A fully equipped individual, realizing his inmost gifts, makes them of value only in the measure that he is willing to lay them on the altar, and serve his fellow-man.

There is a fine sense of the richness of our high calling when we acknowledge this principle of "I Serve." It challenges our very foundations, it tells us that life is not to be measured, or belittled, in emphasizing our mahogany and silver. There could be no real meaning to such effort and accumulation. Better never to have lived than to have become a mere bin, swallowing up the gains of office and practice.

"I Serve" gives meaning to our daily work. There is nothing but sentimentalism in a principle to which we give only lip service, and to which we devote only our leisure moments.

Observe the tide of life ebbing within some vital spirit. How eagerly he clings to just the privileges of another day! The only endowment he holds sacred is the gift of once again putting his feet firmly upon the ground, and answering the call.

There is no sense in mere gain as an end in itself. What can more property or leisure give us? The game is too strenuous unless, behind it, we feel the impulse for a deeper seriousness, founded upon dedication to service. The real worth of life is our personal contribution. To have reached out and touched our fellow-man, to have served him, never to have failed him, are distinction and thrill enough for any man.

"I Serve" will give direction and meaning to 1934.

W. HERBERT MCGUFFIN, M.D.

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## COMMUNICATIONS

### TEXAS RADIOLOGICAL SOCIETY

Those who attended the successful meeting of the Texas Radiological Society on Jan. 8, at Waco, participated in the following program:

Diaphragmatic Study, with Particular Reference to Infection Beneath It. J. B. JOHNSON, M.D., Galveston.

Duodenal Diverticula. R. K. MCHENRY, M.D., Houston.

The Use of the X-ray in Obstetric and Gynecologic Examinations. DAVIS SPANGLER, M.D., Dallas.

Roentgen Diagnosis of Some Conditions in the Lumbar and Sacral Regions. W. G. MCDEED, M.D., Houston.

Requirements for Qualification as an Expert Radiologic Witness. G. E. HENSCHEN, M.D., Sherman.

Surprises Encountered in Routine Radiologic Practice. DALTON RICHARDSON, M.D., Austin.

Radiologic Management of the Malignant Breast. R. H. MILLWEE, M.D., Dallas.

Further Observations in the Roentgen Treatment of Uterine Fibromyomas. C. P. HARRIS, M.D., Houston.

Benign Uterine Hemorrhage. C. L. MARTIN, M.D., Dallas.

An Evaluation of Cholecystography from 500 Cholecystectomies. R. G. GILES, M.D., Temple.

Address: Radiologic Practice and Responsibility. EDWARD H. SKINNER, M.D., Kansas City, Mo.

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### AMERICAN REGISTRY OF RADIOLOGICAL TECHNICIANS

The Board wishes to announce that, beginning January 1, 1934, Mr. Alfred B. Greene has been appointed Executive Secretary of the Board. Mr. Greene is also Executive Secretary-Treasurer of the American Society of Radiographers. His address is Glen Lake Sanatorium, Oak Terrace, Minnesota.

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### IN MEMORIAM

The sad news was received, just before going to press, of the passing on Nov. 30, 1933, of F. D. Crutchfield, M.D., of San Antonio, Texas, a member of this Society. His friends and associates will miss him and the Society will be the poorer for the loss of his contributions to RADIOLOGY.

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### CAUTION

It has been called to our attention that a certain commercial company which has been offering payment for old films has failed to carry out its agreements with radiologists. If further

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The author's use of lipiodol in gynecological examinations is apparently more extensive than in most places in this country, and shows some strikingly good results. There are excellent illustrations of all the important normal and pathologic conditions, as well as a satisfactory discussion concerning them. The work on obstetrics is brief but covers all of the usual conditions fairly well.

In conclusion, there are a few points which should be emphasized. The text all the way through is written in a simple, easily readable style. The illustrations are of a high order and are probably the most valuable feature of the entire work. The author employs all of the newest methods and is thoroughly conversant with the most recent developments in roentgen diagnosis. This work as a whole is a valuable addition to x-ray literature and fulfills the author's purpose in writing it. A complete mastery of the contents should give one a good grasp of the theory of x-ray diagnosis.

THE 1933 YEAR BOOK OF RADIOLOGY. DIAGNOSIS (Edited by CHARLES A. WATERS, M.D., Associate in Roentgenology, Johns Hopkins University), THERAPEUTICS (Edited by IRA I. KAPLAN, B.Sc., M.D., Director, Division of Cancer, Department of Hospitals, City of New York). Cloth, 804 pages and 780 illustrations. Published by Year Book Publishers, Inc., 1933. Price, \$7.00.

The science of radiology has become so involved with the other specialties of medicine that it is almost impossible for even the most ambitious student to keep abreast with the current literature pertaining to it. The 1932 Year Book was hailed as a needed addition to the radiologic literature, but in the present volume the authors have far outstripped their previous efforts. The significant data compiled from 688 important contributions of the past year are presented, together with 780 illustrations. The number of foreign journals reviewed has been considerably increased over the 1932 edition, and the current volume contains references from 125 American and foreign scientific journals. In no other place will one find a better compilation of the latest international developments pertaining to the science of radiology. The text is well arranged, extremely well balanced as to space devoted to the various phases of the subject, and the relation of illustrations to corresponding parts of the text has been improved over the preceding volume. The compilation of this material from the mass of literature pertaining to radiology is no little task and radiologists should be grateful for the untiring efforts of the editors to present the significant current literature of their specialty in a volume that will be looked forward to from year to year.

## ABSTRACTS OF CURRENT LITERATURE

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### THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

J. N. ANÉ, M.D., of New Orleans  
L. J. CARTER, M.D., of Brandon Man., Canada  
H. W. HEPKE, M.D., of Milwaukee

DAVIS H. PARDOLL, M.D., of Chicago  
ERNST A. POHLE, M.D., Ph.D., of Madison, Wis.  
CHARLES G. SUTHERLAND, M.D., Rochester, Minn.

women were treated, but only 181 are used for these statistics. There were 152 cases of carcinoma of the cervix, 16 carcinoma of ovary, 4 sarcoma, 1 carcinoma of the fundus, 1 of the vagina, 1 of the vulva, 1 of the bladder wall, 4 chorio-epithelioma, and 1 "granulosa cell tumor." In 78 out of 152 patients with carcinoma of the cervix, operation was done in 56, radium treatment in 22. They all were treated by roentgen rays prophylactically. At the time of writing the report, 67 were free of recurrence. Of the remaining 74 cases who had x-ray therapy alone, 19 grew worse under the treatment, 39 did not show any effect at all, 12 were improved temporarily, and 4 definitely at the time of publication.

The observations in the other types of growth were essentially the same. Detailed discussion is devoted to the skin reactions, changes of the blood, and modification of the treatment method. The authors feel that not enough material is really available to justify one in rendering final judgment as to the efficacy of the Coutard method in gynecology. They recommend the application of larger single doses, at least in the beginning of the treatment, and the administration of high total doses, at least 4,000 r effective at the site of the disease. Accurate dosage methods are, of course, essential.

ERNST A. POHLE, M.D., Ph.D.

Critical Report as to the Principles and Results in Roentgen Therapy of Carcinoma of the Stomach and Intestines. Paul Krause. *Strahlentherapie*, 1933, XLVII, 125-136.

The author analyzes his experience in roentgen treatment of 25 carcinomas of the stomach, 28 carcinomas of the esophagus, 15 carcinomas in the rectum, 9 of the gall bladder, 2 of the liver, and 2 of the pancreas. The technique of the treatment is briefly outlined. Krause has not seen a cure of carcinoma of the stomach by roentgen rays in a single instance. He mentions, however, that Holfelder has reported encouraging results. He observed one sarcoma of the stomach which responded well to irradiation. In carcinoma of the esophagus and rectum, roentgen therapy did not produce cures. Temporary relief was obtained in some cases of carcinoma of the gall bladder and pancreas.

ERNST A. POHLE, M.D., Ph.D.

The Results of Prophylactic Irradiation of Carcinoma of the Breast following Radical Operation. W. Siemens. *Strahlentherapie*, 1933, XLVII, 627-630.

The author presents the statistics of the Surgical Clinic, University of Kiel, covering their experience with post-operative irradiation of carcinoma of the breast during the period 1908-1929. Out of a total of 508 cases operated upon, 175 were not irradiated and 309 were irradiated. In the statistics, 484 cases are evaluated. Three groups were used, based on clinical examination. In Group I the tumor was limited to the breast, in Group II, *a*, *b*, and *c* graded involvement

of glands, skin, and muscles, and Group III included the far advanced cases. It appeared that in Group I prophylactic irradiation did not add anything to the end-results as compared with operation alone. However, in Group II, *a* and *b* (33.6 per cent) were alive after five years with operation alone, while following operation and irradiation 53.2 survived. The author concludes that his clinic will continue to use post-operative irradiation in carcinoma of the breast, and he points out that in his second group, namely, those patients with moderate involvement of the axillary glands, the benefit from the treatment is most striking.

ERNST A. POHLE, M.D., Ph.D.

The Radiation Treatment of Intra-oral Cancer. C. W. Prowd. *Canad. Med. Assn. Jour.*, February, 1933, XXVIII, 182-184.

In actual practice present-day conditions call for close co-operation between radiation therapists and surgeons in the treatment of intra-oral cancer.

The first consideration is intra-oral asepsis, radium and x-ray treatment of mouth conditions being doomed to failure in the presence of mouth infection. Warning should be given the patient of the period of reaction, lasting from six to eight weeks. The cheeks and anterior half of the tongue are accessible to radium element or radon seed implantation from within or without. The floor of the mouth we have found to respond better to topical applications than radium implants. This is true also of the under surface of the tongue and the gums. Electro-coagulation immediately follows radiation. The tonsils, pharynx, and soft palate are best treated by radon seeds or radium element.

All cases of tongue, floor of mouth, tonsil, and pharyngeal cancers are given supplementary x-ray to the submaxillary areas and neck triangles. This treatment should be pre- and post-radium.

The author records 158 cases of oral carcinoma observed over a period of six years (1926-1931). Of these, 45 (28.8 per cent) had palpable submaxillary glands on one or both sides, and 78, or exactly 50 per cent of all cases, are dead. No case with involved glands lived more than three years.

L. J. CARTER, M.D.

Radiation in Primary Operable Breast Cancer. Douglas Quick. *Jour. Am. Med. Assn.*, Dec. 30, 1933, CI, 2091-2096.

Until recently, radiation has been limited to post-operative therapy and to the palliative care of inoperable, recurrent, and metastatic growths. In only a limited way has there been a close co-operation between surgery and radiation therapy in the field of breast cancer. There is now sufficient reliable published information and an accumulation of experience to warrant a reappraisal of the situation. Accumulated experience is sufficient to warrant advancing of the status of radiation in the breast group. It deserves initial consideration in the entire primary operable group—not in a competitive but in a co-operative way. Strictly oper-



## BONE DISEASES (DIAGNOSIS)

**Osteopoikilosis** Case Report. Hugh Jeter and Charles L. McGehee Jour Bone and Joint Surg, October, 1933, XV, 990-992

The authors report a case of osteopoikilosis, which occurred in a white male, 37 years of age. The patient, who was a World War veteran, was examined by means of the x-ray for shrapnel wound of the shoulder. The roentgenogram revealed, besides the metallic foreign bodies, scattered, small, dense areas about the metaphysis and epiphysis of the humerus. The patient stated that the condition had been discovered 14 years previously. X-ray examination of the skeleton showed the presence of similar areas in the bones of the feet, hands, arms, legs, pelvis and scapulae. The bones of the spine, ribs and skull showed no evidence of such changes.

J. N. ANÉ, M.D.

**Bilateral Disease of the Internal Cuneiform Bone, with an Associated Disease of the Right Scaphoid Bone (Köhler's)** Edward J. Haboush Jour Am Med Assn, Jan 7, 1933, C, 41

A group of closely related disorders of bone are those known as Legg-Perthes disease of the femoral capital epiphysis, Köhler's disease of the tarsal scaphoid, Osgood-Schlatter's disease involving the epiphysis of the tibial tubercle, Kienbock's disease affecting the semilunar bone of the wrist, and Freiberg's infraction of the second metatarsal head. Most authors are of the opinion that the underlying pathologic condition in these bone disorders is microscopically an aseptic necrosis. Some authorities have observed an infiltration of the bone with fibrous tissue extending from the periosteum. Others have found cystic formation with fibrous tissue infiltration, and some report the changes of an osteochondritis. The author reports a case of bilateral disease of the internal cuneiform, with an associated disease of the right tarsal scaphoid bone (Köhler's). A careful search of the literature failed to reveal any case with similar pathologic changes.

C. G. SUTHERLAND, M.D.

## CALCULI

**A Case of Renal and Ureteric Calculi of Unusual Size. Repeated Formation of Calculi** Edgar Freshman British Jour Surg, July, 1933, XXI, 63-66

The case reported is an interesting example of "continuous" stone formation in the urinary tract, and illustrates the enormous size that may be attained by calculi before they give rise to symptoms severe enough to induce the patient to seek relief.

The rate at which they were formed in this particular case is worthy of note. All calculi visible on x-ray examination were passed *per urethram* or removed from the left kidney in July, 1923. Four months later two calculi were found in the opposite kidney and one in the bladder. Ten months after this, another, which, according to the symptoms had also come from the right

side, was passed and two more were removed from the pelvis of the left kidney, *i. e.*, fourteen months after nephrolithotomy had been performed on that side. An interval of nearly six years elapsed before the onset of symptoms suggesting the presence of further calculi. None of the stones had a core of pure uric acid which might have accounted for the existence of the stones some time before becoming opaque to the x-ray. A radiograph demonstrating the renal and ureteric calculi with their measurements and weights accompanies the article.

DAVIS H. PARDOLL, M.D.

## CANCER (DIAGNOSIS)

**A New Method of Roentgenologic Demonstration of Rectal Carcinomas** O. Fricke Röntgenpraxis, May 1933, V, 365-368

Roentgenologic demonstration of rectal carcinomas has been unsatisfactory heretofore and has seemed unnecessary in cases in which the situation and size of the carcinoma could be determined clinically (digital examination, proctoscopy). It is not always possible to get a correct picture of the size and situation of the carcinoma by these clinical methods, and yet for the surgeon these factors are of great importance. The author has devised a simple and effective method of roentgenologic demonstration of such tumors. He fastens a rubber condom on the end of a duodenal tube which has a metallic button on its tip. Enough barium is introduced into the rectum to reach the sigmoid, it is then again aspirated so as to leave just enough to cover the walls of the rectum. The duodenal tube with the non-inflated rubber condom is introduced by means of a wire or a half stiff silk catheter. After the rubber condom has been put in the correct position, it is inflated by air and a roentgenogram is made. Reproductions of such roentgenograms show the location and size of carcinomas nicely. The author believes that the method is of great help for determining the type of operation.

H. W. HEFKE, M.D.

## CANCER (THERAPY)

**Protracted Fractional Roentgen Therapy in Carcinoma of the Female Genital Organs** Heinz Kirchhoff and R. Winckler Strahlentherapie, 1933, XLVII, 601-626

The authors report the experience of the Women's Clinic at the University of Kiel with the use of the Coutard treatment method in carcinoma of the uterus and ovary. They used, as a rule, 180 K.V. 4 ma., 2.3 mm. Cu (half value layer in Cu 2.0 mm.), 50-70 cm. F.S.D., 2.2-6 r per minute. Later the filter was reduced to 1.5 mm. Cu. One large area was exposed over the abdomen and two areas over the back. The dose per field amounted to 200 r (in air), or 268 r on the surface. Each skin area was exposed from eight to twelve times so that most patients received a dose of from 2,400 to 4,000 r effective in the tumor. In this way 220

## ESOPHAGUS (DIAGNOSIS)

A Case of Polyps in the Esophagus N A Podkaminsky Röntgenpraxis, May, 1933, V, 353, 354

A 29-year-old man complained of inability to swallow, gradually getting worse during two years. Roentgenologic examination of the esophagus showed a narrowing in its cardiac portions by a smooth, well circumscribed tumor. Infiltration of the wall of the esophagus could not be demonstrated. Barium passed into the stomach only after a half-hour. Above the narrowing the esophagus widened. Because of the youth of the patient, the long history of dysphagia, and the roentgenologic signs a benign tumor of the esophagus was suspected—and proven by esophagoscopy. Five benign polyps of the mucoid type were removed.

H W HEFKE, M D

## ESOPHAGUS (THERAPY)

Development of Diverticula of the Esophagus following Roentgen Therapy of Intrathoracic Tumors Arnold Herzog Strahlentherapie, 1933, XLVII, 795-797

The author observed two patients in whom definite traction diverticula developed following roentgen-therapy applied to the chest for neoplasm of the lung or the mediastinum. The histories of these cases are briefly given, and roentgenograms show the diverticula. The author suggests the study of cases of this type, combined with search for traction diverticula.

ERNST A POHLE, M D, Ph D

A Rubber Esophagus London letter quoting Arthur Edmunds Jour Am Med Assn, April 29, C, 1352

A case is reported in which a rubber tube was substituted for a large part of the esophagus, with almost complete restoration of function. The patient was a woman, aged 40, from whom had been removed the larynx, part of the pharynx, the cervical esophagus, and a considerable part of the thoracic esophagus for squamous-cell carcinoma. The operation necessitated a permanent tracheotomy and a gastrotomy. By establishing a pharyngeal sinus in the neck just below the hyoid bone, the surgeon was able to introduce the short end of a wide rubber empvema tube into the upper pharynx. This tube was made secure in the neck by tapes passing through the holes in the flanges, and was connected by a long rubber tube with the gastrotomy opening, thus producing an external rubber esophagus. The device functioned well and no secondary growths followed.

Now 23 years after the operation, the patient is alive and well and able to enjoy life. She complains only that, if she catches cold the coughing upsets her and produces some chafing at the entrance of the tube into the stomach. The tubes are taken out regularly and boiled, and there is no unpleasantness from decomposing food. She can wear a dress that entirely conceals her condition from observers. She has of

course, lost her voice, but she has cultivated a whisper which is sufficient for social intercourse. She is able to take and masticate ordinary food, both solid and liquid, and to swallow it through the rubber esophagus.

C G SUTHERLAND, M D

## THE FOOT

The Prehallux in Relation to Flatfoot F C Kidner Jour Am Med Assn, Nov 11, 1933, CI, 1539-1542

The prehallux, or accessory scaphoid, is a common and frequently unrecognized anomaly which, by changes in the leverage, interferes with the normal mechanics of the action of the posterior tibial muscle and thus produces weakness of the longitudinal arch and flatfoot of a type highly resistant to the usual conservative methods of treatment. In the presence of the prehallux, whether as a separate bone or as a prolongation inward of the scaphoid, there is an abnormal insertion of the tibialis posticus tendon. It has been found that in many cases of flatfoot in which the prehallux is absent the same abnormal course of the posterior tibial tendon is seen. In the presence of the prehallux, the outward excursion of the scaphoid on the head of the astragalus is increased, so that the motion of the astragaloscaphoid joint is abnormally great, producing what is, in effect, an outward subluxation of the whole forefoot or an inward subluxation of the anterior end of the astragalus. This leads to a considerable increase of ligament strain, with marked pain and foot weakness.

C G SUTHERLAND, M D

## FOREIGN BODIES

Needles in the Deep Urethra, Stone and Periurethral Abscess Case Report in 7-year-old Boy Meredith Campbell Am Jour Surg, September, 1933, XXI, 452, 453

Masturbation in children by the introduction of foreign bodies into the urethra is not uncommon but seldom is the stimulant object lost in the canal. The following case is of interest because two long darning needles were thus deposited in the deep urethra of a 7-year-old boy, yet it is reported because it admirably illustrates (1) the usual complications of urethral foreign body, (2) the likelihood that the erroneous diagnosis of gonorrhea will be made, and (3) the type of treatment required when the foreign body is large or peri-urethral suppuration exists.

DAVIS H PARDOLL, M D

## FRACTURES (THERAPY)

Fractures of the Ankle Recent and Old Melvin S Henderson and Walter G Stuck Jour Bone and Joint Surg, October, 1933, XV, 882-888

The authors reviewed the histories of all cases with fracture of the ankle treated in the Orthopedic Section of the Mayo Clinic from 1909 to 1933, consisting of 479

able tumors in elderly persons may well be a problem for radiation therapy rather than for surgery. The same may be true for the very young. Advanced growths, still considered operable by many surgeons, will probably do better by radiation than by surgery. When the evidence is carefully gone over, the fact remains that of all patients coming to operation at least 70 per cent are dead from extension of the disease at the end of five years, and that the majority of the remaining 30 per cent die of cancer ultimately. It seems evident that radiation therapy should be pressed more aggressively in the so-called operable stages of breast cancer, rather than limited to the follow up phase of therapy. Continued study, correlation of the microscopic changes with the clinical reaction to radiation, will go far toward pointing out those groups most amenable to radiation therapy. In early breast cancer there seems little doubt but that roentgen radiation occupies the major position. Radium occupies a limited, but valuable place, and always for implantation. Occasionally, a primary tumor assigned wholly to radiation requires implantation and, at operation, radium by implantation may frequently be used to advantage in the axilla or the upper intercostal spaces adjacent to the sternum. For these purposes radon in gold seeds affords a wide range of flexibility in application and is much less damaging from the standpoint of trauma. Radium or radon implantation should always follow rather than precede the roentgen irradiation. While the ovarian hormone evidently exerts an influence on the development of some breast cancers, there is no substantial evidence to warrant castration by radiation as a therapeutic aid. Biopsy is safe if carefully done after preliminary radiation. The same degree of attention should be given to technical detail in radiation therapy as in surgery.

C G SUTHERLAND, M D

### CONTRAST MEDIA

Hazards of Iodized Oil Injections. Editorial. Jour Am Med Assn, Jan 7, 1933, C, 46.

Sometimes the possibilities of hazard inherent in a new method have been dimmed by the promising diagnostic aid for the primary pathologic condition. As medical experience has matured, the limitations of the roentgen ray and radium are becoming more and more circumscribed, inexperienced use of these potent forms of energy brought early unfortunate accidents and death to members of the profession. It has been ten years since the iodized oils were introduced as diagnostic agents. Experience has proved that injection and retention in the body of these oils are not without danger. Accidents have occurred—some serious, a few fatal. Tuberculous lesions are often unduly irritated, embolic phenomena have been noted, inflammatory reactions are not infrequently induced by the retained oil. The reports of the Council on Pharmacy and Chemistry emphasize the insistence on due caution in the use of all new methods and preparations until their potentialities for doing damage have been subjected to the test of scientific scrutiny.

C G SUTHERLAND, M D

### DIAPHRAGMATIC HERNIA

Diaphragmatic Hernia. W H Dickson. Canad Med Assn Jour, July, 1933, XXIX, 24-31.

The symptoms and physical signs of diaphragmatic hernia are so indefinite that clinical diagnosis is very rare. Griffin, in 1912, collected the reports of 650 cases, of which only 12 were correctly diagnosed during the patient's lifetime.

Coincident with the application of radiology to the gastro-intestinal tract all the varieties of diaphragmatic hernia have been shown to be of frequent occurrence.

Hernia of the stomach through the hiatus esophagei constitutes the largest group. It is both congenital and acquired, the congenital being the more common form. Other abnormalities which may be confused with it are diverticula at the lower end of the esophagus and diverticula at the cardiac end of the stomach. The next most frequent variety is through the left diaphragm. The only source of error is eventration of the left diaphragm. Hernia of the right diaphragm is rare—when this lesion is suspected a pneumopertoneum must be done. A defective embryologic development of the hepatic flexure may be a source of error in such a case.

L J CARTER, M D

### DOSAGE

Clinical Experimental Observations Concerning the Fractional Dose Method in Irradiation of Cancer. F Keller. Strahlentherapie, 1933, XLVII, 636-645.

The author studied the effect of fractional doses on the skin of mice by applying daily  $\frac{1}{2}$  H E D. He could administer two and one-third times the dose which would epilate if applied in a single sitting. The treatment of tumors in animals was not markedly successful. Quite striking was the systemic reaction of the animals treated with fractional doses. An attempt to use this treatment method clinically was not successful, more complications being seen than after the usual method of administration. His experience is based on five patients with carcinoma of the cervix.

ERNST A. POHLE, M D, Ph D

Comparison of Skin Reactions under Different Methods of Administration. R Pape. Strahlen therapie, 1933, XLVIII 73-96.

According to the author the skin reactions depend chiefly on four factors: (1) The total dose, (2) the number of r per minute administered, (3) the total time of treatment, (4) the number of fractional doses. He studied experimentally one special case, namely the equivalent doses for a fractional application consisting of two sittings and a single dose, both producing the same skin reactions. It appeared that the reactions were equal if the total duration of the exposures was proportional to the number of r per minute applied in each case.

ERNST A. POHLE, M D, Ph D

last has been *nil*. A series of tables detail the various forms of diet used in types of cases

C G SUTHERLAND, M D

### GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Intestine as an Excretory Organ Editorial  
*Jour Am Med Assn*, April 22, 1933, C, 1253

Recently physiologists have begun to realize the importance of the bowel as an organ of excretion by this is meant not the removal of materials that have failed to be digested and absorbed. The feces also contain substances secreted into the lumen of the intestine for excretory purposes. This applies notably to iron, calcium, and magnesium as well as to certain foreign elements. The large intestine may be regarded as the principal channel for the excretion of insoluble substances that cannot be easily passed out by the kidneys.

Williams and Dick have pointed out that the excretion of water by the intestine has long been recognized as a useful therapeutic procedure, but little emphasis has been placed on the substances excreted with the liquid. The action of the saline cathartics is generally regarded as being due to the large amount of liquid that is abstracted from the blood through the intestinal mucosa by the hypertonic solution. According to them, appreciable amounts of the non-protein nitrogen metabolites are eliminated in the stools by purgation. The higher the concentration of non-protein nitrogen in the blood, the higher is the concentration in the liquid feces. The therapeutic efficacy of vigorous catharsis and purging is supported by experimental evidence. Sometimes the concentration of nitrogen in the purgation stools was greater than that in the blood. In any event, new interest has become centered in the possible value of the saline cathartics and hydragogues in the treatment of chronic nephritis and chronic myocarditis.

C G SUTHERLAND, M D

Congenital Obstruction of the Small Intestine William E Ladd *Jour Am Med Assn*, Nov 4, 1933, CI, 1453-1458

This is a study of 60 cases occurring in the Children's Hospital of Boston. Only those cases were included in which the obstruction was located in the small intestine and was due to one of two factors. Intrinsic obstruction is the interference in the continuity of the lumen of the intestine due to intra intestinal defects, while extrinsic obstruction is the interference in the function of the intestine by external pressure due to faulty rotation. Obstruction caused by bands which may or may not be of congenital origin and that due to hernias and the vagaries of Meckel's diverticulum were not included. The normal embryologic development of the intestine is discussed, with the results of arrest in development during this period and the variety of conditions presented in extrinsic obstruction due to faulty rotation. Roentgen examinations, with and without the

administration of contrast media, are of great assistance in diagnosis. The point of obstruction, if complete, is clearly identified by the outline of the gas above the blind end. The administration of barium is contra-indicated if one suspects a complete obstruction. Reports of typical cases are given in detail.

C G SUTHERLAND, M D

Treatment of Acute Intestinal Obstruction by Suction with the Duodenal Tube Owen H Wangenstein and John R Paine *Jour Am Med Assn*, Nov 11, 1933, CI, 1532-1539

In this essay on the treatment of acute intestinal obstruction by suction with the duodenal tube a clinical classification is charted with that of the pathologic and the treatment of the various forms. The contra-indications to the use of this form of treatment are outlined. The x-ray film is an aid of value not only in determining the presence of obstruction but also in deciding its location, as well as in the decision as to whether the obstruction is complete or incomplete. The visualization of gas in the small bowel of the adult is synonymous with stasis. A single x-ray film taken with the patient supine gives more information than plates taken in any other position. It reveals the grade of intestinal distention present and affords fairly reliable evidence as to its location. Roentgen studies made with an enema of barium sulphate are unnecessary and are contra-indicated in acute obstructions except in intestinal atresia and in cases in which the conjectured presence of an obstruction in the descending colon would appear to need verification by an enema of barium sulphate.

In a patient having intestinal colic in whose bowel the distention involves, and is limited solely to, the colon, the diagnosis of obstruction in the descending colon is practically established. If loops of small intestine are distended but gas is also present in the colon, the patient in all likelihood has a partial obstruction of the small intestine. Distention of the small intestine alone without visible gas in the colon means that the obstruction is complete. From inspection of the roentgen film of the abdomen, one cannot predict the exact location of an obstruction in the small intestine with the same precision as in the colon. On the whole, however, it may be determined with fair accuracy whether the obstruction is in the upper, lower, or middle third of the small intestine.

C G SUTHERLAND, M D

### GASTRO-INTESTINAL TRACT (THERAPY)

Retrograde Intussusception of Jejunum Ralph B Bettman and Robert S Baldwin *Jour Am Med Assn*, April 22, 1933, C, 1128

The authors have been able to find 32 cases on record, exclusive of the one here reported, of this condition complicating gastro-enterostomy. The American literature contained only five case reports. Following a gastro-enterostomy twelve years previously their

patients, of whom 139 had recent fractures of the ankle and 340 had old fractures

This statistical study shows in particular the great importance of early diagnosis and recognition of the extent of injury and early accurate reduction, followed by careful and adequate immobilization. This is particularly true in the "trimalleolar" fracture, first described by one of the authors.

The "trimalleolar" fracture consists of the clinical Pott's fracture, plus fracture of the posterior malleolus, with encroachment on the weight-bearing surface of the astragalus. This is usually accompanied by posterior and upward dislocation of the astragalus, manifested clinically as posterior displacement of the foot.

The treatment of recent fractures should be as conservative as possible. Malleolar fractures without displacement should be treated by splinting or strapping. In cases of deformity, manipulation and immobilization in a plaster cast are indicated.

Roentgenograms should be made in two planes before and after reduction. After reduction the anteroposterior view should show the normal convexity of the tibia fitting accurately into the normal concavity of the astragalus. In the lateral view the convexity of the superior surface of the astragalus should fit the concave articular surface of the tibia accurately.

Among the 340 patients with old fracture of the ankle who came to the Clinic because of pain, swelling, limitation of motion, deformity, or weakness, it is interesting to note that in many cases roentgenograms had not been made, either at the time of the accident or later. The authors believe that this omission was due to inaccessibility of roentgen ray equipment and unwillingness of patients to submit to the examination.

J N ANÉ, M D

## GALL BLADDER (NORMAL AND PATHOLOGIC)

Persisting Errors in the Technique of Oral Cholecystography. A Procedure Designed to Avoid Them. B R Kirklin. Jour Am Med Assn, Dec 30, 1933, CI, 2103-2105.

The author has become thoroughly convinced that when the oral method is properly executed, its efficiency is equal to that of the intravenous method and that adverse comparisons of the two methods are based usually on results derived from faulty oral techniques. To employ the oral test effectively, the dye must be given (1) in sufficient quantity, (2) in readily absorbable form, (3) in such a manner that it will not produce undue nausea or purgation and (4) under conditions that will not hamper its evacuation from the stomach, its absorption from the bowel, or its accumulation and concentration in a normal gall bladder. Sodium tetraiodophenolphthalein (tetiophthalein) is given in a unit form dose of 4 gm to adults, reduced for children in proportion to weight, but not varied for small or large adults. The compound is given in solution, freshly prepared, in such a manner that it will be palatable and well borne by the stomach. The most satisfactory method has been to mix it with grape juice, other fruit

juices, or carbonated water. The most important factor, in his experience, has been the settling on a fixed routine of requiring the patient to take a full meal containing a minimum of fat and following it immediately with the dye. Much fat in the meal will lead to a high proportion of mistakes in diagnosis. To avoid interference with absorption of the dye or with its entrance into and concentration by the gall bladder, purgatives, especially castor oil, and other medicines which affect the intestine or biliary organs, should not be taken by the patient during or shortly prior to the examination. Cleansing of the large bowel is best effected by having the patient employ enemas on the morning of examination.

A review of the cholecystographic data for the year 1932 shows that of 732 patients operated on, the cholecystographic diagnosis, whether positive or negative, was confirmed in 95 per cent.

C G SUTHERLAND, M D

Dietary and Medical Management of Diseases of the Gall Bladder. Newer Points of View. John Russell Twiss and Carl H Greene. Jour Am Med Assn, Dec 9, 1933, CI, 1841.

A critical review of the literature on the anatomy, physiology, chemistry, and pathology of the liver and biliary tract, summarizing new points of view for the study of the disease process, the developments of new technical methods of examination or advances in any of the medical sciences, prefaces this discussion.

The function of the gall bladder is to provide a reserve of concentrated bile, of value both in digestion and as a means of stimulating the liver to increased activity at the time the gastro-intestinal tract is most active. An extensive experimental literature indicates that the gall bladder perhaps never empties completely, as does the urinary bladder, and several days may elapse before the entire contents at any one particular time is removed. The question of the mechanism involved in the emptying of the gall bladder into the duodenum embraces the effect of respiratory movements, changes in intra abdominal pressure, the elasticity of the viscus, variations in the tone of the duodenal wall or of the sphincter of Oddi, and the existence of a reciprocal innervation between the sphincter and the gall bladder.

If medical therapy is ever to supplant surgery in this field of medicine, it will be necessary to recognize and correct disturbances in the biliary tract before the formation of calculi. Various predisposing causes to be considered are biliary stasis, infective disturbances in pigment excretion or cholesterol metabolism, obesity and pregnancy. The authors have found non surgical biliary tract drainage a valuable supplementary method of diagnosis, provided the drainage is properly performed and the results are correctly interpreted. The general plan of medical treatment is considered under the headings of (1) prevention of biliary stasis, (2) prevention or treatment of inflammation of the gall bladder or bile ducts, (3) diet, and (4) removal of calculi when once formed. Progress other than surgical in the

## GYNECOLOGY AND OBSTETRICS

Dilatation of the Kidney Pelvis and Ureter during Pregnancy and the Puerperium Herman L Kretschmer, N Sproat Heaney, and Eugene A Ockuly Jour Am Med Assn, Dec 23, 1933, CI, 2025

The authors studied a series of cases by intravenous pyelography, selecting only such women as gave normal kidney and bladder histories and who were normal as to urinary examinations and obstetric conditions at the time Thirty-one cases were followed from early pregnancy through the delivery and the puerperium until the kidney and ureteral conditions were normal At some time during pregnancy, dilatation was found in 97.6 per cent of the group One patient showed a mild dilatation of the calices and lumbar ureter on the left side ten days after delivery, so, therefore, 100 per cent showed evidence of dilatation at some time during pregnancy or after delivery

The striking feature about the dilatation of the ureter during pregnancy was that the dilatation was almost universally above the brim of the pelvis As a rule, the dilatation is progressive, along with the pregnancy Lateral displacement of the ureter, when found early in pregnancy, tends to increase as the pregnancy advances In none of these cases did pyelitis develop during pregnancy, although marked dilatation and lateral displacement were present Presentation and position of the fetus could not be brought into causative relationship with dilatation or displacement

C G SUTHERLAND, M D

Roentgen Rays in the Diagnosis of Placenta Praevia London letter quoting Munro Kerr and W G Mackay Jour Am Med Assn, Feb 25, 1933, C, 587

The authors first injected strontium iodide into the amniotic sac The fetus died in three of ten cases The authors then substituted a derivative of iopax, non-toxic and non irritant, and found that 20 cc would produce a suitable shadow In ten cases, no untoward effects occurred to either the fetus or the mother, though the injection had a great tendency to terminate the pregnancy It was necessary to take at least two roentgenograms, one anteroposterior and the other lateral, to be sure of getting a full view of the indentation made by the placenta In placenta praevia the roentgenograms showed how much of the placenta was in the lower segment and covered the os It was also shown that in certain cases the sex of the child could be diagnosed and the film also showed whether or not any coils of cord were round the child's neck

C G SUTHERLAND, M D

## HEART AND VASCULAR SYSTEM

Cardiac Roentgenoscopy M C Morrison Canad Med Assn Jour, July, 1933, XXIX, 51-55

The x-ray has provided two chief methods of study

of the heart—roentgenoscopy and teleroentgenography The author discusses the former

The roentgenoscopic examination of the heart provides a method of ascertaining cardiac mobility, and also permits, through the orthodiagraph or fluoroscopic tracing, an accurate record of cardiac size and movement The experienced observer is permitted to study the force, tone, co-ordination, organization, and the presence of excessive or insufficient motion He can also determine the intrinsic motion of the various chambers, and the transmitted motion of the heart as a whole, together with its relations to the other structures of the chest

L J CARTER, M D

The Roentgenologic Diagnosis of Calcification of the Heart. G W Parade and F Kuhlmann Röntgenpraxis, May, 1933, V, 341-346

Roentgenologic observation of calcification in pericardium and myocardium has been reported rather often A diagnosis of calcification in the connective tissue of the heart, however, during life appears to be rare According to Giese, who studied these calcifications from an anatomic-pathologic standpoint (with roentgenograms of postmortem hearts), calcification is most common in the sclerotic tissue at the base of the mitral valve, the so-called annulus fibrosus—the sclerotic portion of the aortic valves These calcifications are predominantly found in old persons and are degenerative processes Calcification on an inflammatory base is much rarer Sunmonds was the first author to demonstrate these changes roentgenologically, and a few other authors have reported similar cases

Three patients with calcification of the mitral-ring and one case of calcification of the aortic valve were observed by the authors This latter is, so far as the authors know, the first such case diagnosed roentgenologically during the life of the patient In all cases the calcification was not homogeneous, but irregular and nodular, like a string of pearls The calcification of the aortic valves showed a ringlike arrangement in the authors' case

Fluoroscopic examination is necessary in order to locate the calcified areas They seem to move almost horizontally toward the left and a little downward with the beginning of the systole, at the end of the systole they move upward and return to the original position during the diastole The calcified aortic valve moved toward the base of the heart during diastole, the extent of its movement being considerably less than that of the calcified mitral valve In one case autopsy proved the roentgenologic diagnosis

H W HEFKE, M D

Coarctation of the Aorta Ten Years' Observation of a Patient Still Living M J Shapiro Jour Am Med Assn, March 4, 1933, C, 640-642

Coarctation of the aorta is a term used to designate a narrowing or complete obliteration of the aorta, usu-

patient had been in excellent condition until six days previously, when, after a full day's work of heavy manual labor, he experienced a sharp pain in the upper abdomen. The pain was quite severe, but was relieved when he vomited. In a few hours the pain returned with such severity that he was hospitalized. He continued to vomit and in a few hours the vomitus contained bright red blood and later became feculent. After five days' expectant treatment he was transferred to the surgical group and a laparotomy was performed. A retrograde intussusception of 120 cm was found starting in the efferent jejunal loop of the anastomosis about 30 cm from the stomach, and extending through the gastro-enterostomy into the stomach itself. The intussusception was readily disinvaginated, but the intestine was found to be gangrenous. A portion of the bowel was exteriorized and a jejunostomy was done. The patient continued in poor condition and died two days later.

A review of the literature follows, which shows that early operation consisting of simple reduction of the intussusception was successful in over 90 per cent of the cases.

C G SUTHERLAND, M D

### GENITO-URINARY TRACT (DIAGNOSIS)

Hemiponephrosis in Infants and Children. Meredith Campbell. *Am Jour Surg*, July, 1933, XXI, 85-96.

Five cases of hemiponephrosis in very young children are reported. Being anomalous, reduplicated kidneys are more prone to disease than are normal organs. The condition illustrates another lesion which may cause persistent urinary infections in juveniles and, because of pyuria, commonly leads to the diagnosis of chronic pyelitis. The correct diagnosis of hemiponephrosis is made by urologic examination. When half of the double kidney remains undiseased, and the operation is technically feasible (the condition of the patient permitting) ureteroheminephrectomy is the treatment of choice. With marked renal infection, especially acute, nephrectomy is often the wiser course. In the youngest patient of this series, ureteroheminephrectomy was successfully performed at the age of six months. Several pyelograms and illustrative drawings accompany the article.

DAVIS H PARDOLL, M D

Intravenous Urography in the Diagnosis of Rupture of the Bladder. Ernest G Mark. *Jour Am Med Assn*, Jan 7, 1933, C, 42.

In the gathered statistics of de Tarnowsky it is quite definitely shown that when a diagnosis has been made and operative procedure instituted within the first 12 hours following injury, the mortality has been approximately 11 per cent. Postponed for 24 hours, the mortality has risen to 55 per cent. The innocuousness of the more recent media for intravenous urography

suggested their use in the diagnosis of a ruptured bladder in this writer's case. Thirty five c.c. of 40 per cent skiodan was given intravenously while the patient was on a Bucky diaphragm table. Roentgenograms at seven minutes and fifteen minutes after injection showed an extra-peritoneal rupture into the space of Retzius, with an extravasation most marked on the left. Immediate operation substantiated the diagnosis and repair was made. The post-operative course up to 11 days later was uneventful.

C G SUTHERLAND, M D

Vascular Obstruction of the Ureter in Juveniles. Meredith Campbell. *Am Jour Surg*, December, 1933, XXII, 527-541.

Seven proved cases and one probable instance of vascular ureteral obstruction in juveniles are reported. Loin pain is a frequent symptom. When infection, with pyuria, exists, "chronic pyelitis" is the usual diagnosis. When infection is slight or absent, the clinical diagnosis, based on urinalysis, is likely to be chronic interstitial nephritis. The existent nephritis is regularly of the toxic variety in the unobstructed organ and of the compression or back-pressure type in the obstructed kidney. This nephritis may be expected to disappear following removal or adequate treatment of the seriously diseased mate. Only by complete urologic examination with urography can an accurate diagnosis be made pre-operatively. Conservation surgery, chiefly vessel resection or ureteroplasty, is urged, while nephrectomy is indicated in cases of far-advanced renal destruction, infection, or calculus disease. By specific example, these cases serve to emphasize the great importance of early diagnosis and treatment of persistent urinary tract disease in young patients.

Many interesting roentgenograms and reproductions of pathologic specimens accompany the article.

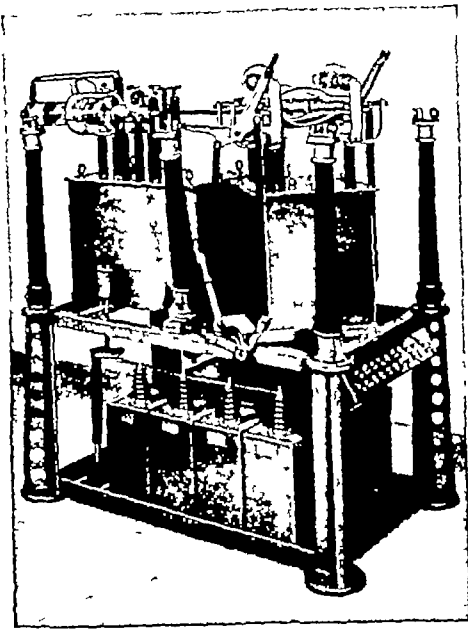
DAVIS H PARDOLL, M D

### GENITO-URINARY TRACT (THERAPY)

Urachal Cysts and Fistulae. Marion Douglass. *Am Jour Surg*, December, 1933, XXII, 557-560.

The author reports two cases in which it seems likely that injury to the urachus was the condition responsible for the midline wound infection, which persisted, apparently without cause, over a long period of time. The generalization may be made that very slight urinary leakage may be responsible for similar lesions and for hernias occurring in obscurely infected wounds as well. It seems worth while therefore, in making gynecologic incisions, if the urachus cannot be pushed to one side or the other and is not clearly obliterated, especially at its lower portion toward the bladder, that it should be picked up and if there is the slightest question of its possible patency, should be ligated firmly.

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ally in the region of the insertion of the ligamentum arteriosum, the vestigial ductus botalli, distal to the origin of the subclavian artery. There are two forms, infantile and adult. The former represents a persistence of intra-uterine circulation and is incompatible with life. The adult form consists of a sharp narrowing, even to the extent of complete obliteration, in the immediate vicinity of the insertion of the ductus botalli. The diagnosis is made on four characteristic observations: hypertension of the upper extremities, lowered or absent blood pressure of the lower extremities, evidence of collateral circulation, and erosion of the ribs as demonstrated by roentgen examination. The erosion is caused by the dilated and tortuous intercostal arteries, which carry the brunt of the collateral circulation made necessary by the narrowing or complete obliteration of the aorta. Enlargement of the heart, especially of the left ventricle, is quite common but may not be present. The roentgenogram shows the erosion and scalloping of the ribs.

C. G. SUTHERLAND, M. D.

## HEMATURIA

An Investigation of 742 Cases of Hematuria. R. K. Debenham. *British Jour. Surg.*, July, 1933, XXI, 44-62.

In analyzing 742 cases of hematuria the author has arrived at the following conclusions. In men the most frequent causes of bleeding are papilloma and carcinoma of the bladder, while in women inflammatory conditions of the urinary tract seem to be the most prevalent cause. When hematuria is the presenting symptom in men the chances are that it is due to either papilloma or carcinoma of the bladder in 50 per cent of the cases. It seems, however, in women the cause is as likely to be inflammatory as neoplastic. When hematuria occurs as an only symptom (65 cases), there is a two-to-one chance that it may be due to the same condition as above, whereas in women (10 cases) the commonest causes was renal calculi.

The prostate assumes the leading role as a common cause of hematuria in men at the age of fifty or beyond. Illustrative of the above may be cited the following: In 130 cases of hematuria in men over sixty years of age, 43 per cent were suffering from papilloma or carcinoma of the bladder, and 37 per cent from either simple or malignant enlargement of the prostate. Not infrequently both carcinoma of the bladder and prostatic enlargement are associated. The symptoms in some cases are rather similar and unless cystoscopy is performed a case may for a time be considered to be one of prostatic enlargement, resulting in the loss of valuable time.

When hematuria is classified according to the various decades of life it is found that the first and second are relatively free of bleeding. Inflammatory conditions and calculi are most frequently found as a cause in

both sexes during the second and third decades. Neoplasm becomes the commonest cause of hematuria in men in the fifth decade of life and in both sexes in the sixth decade.

Carcinoma of the kidney is rare—it was the cause of only 2.5 per cent of all the reported upon cases of hematuria and was found six times oftener in men than in women. Not uncommonly painless hematuria may be caused by renal calculi. The diagnosis of hematuria due to varicose vesical veins must be made with great caution, unless the bleeding is actually seen to be coming from a varix. It is imperative that a cystoscopy be done during the attack of bleeding in order to determine, if possible, the source. On the other hand, best results in cases suggestive of carcinoma vesicae, with foul urine containing much blood, are usually obtained after several days in bed and lavage of the bladder.

Of the 66 cases of unexplained hematuria, 49 were traced, and the subsequent history and findings disclosed that, of these, four cases (8 per cent) reported that calculi had been either passed or removed, 33 (67 per cent) were almost well, no more bleeding having occurred, eight (16 per cent) reported recurrence of bleeding on one or more occasions. All were well or only slightly inconvenienced except one man who had syphilis and had become blind, and four (8 per cent) had died, two of acute lung conditions unassociated with the hematuria, one of carcinoma of the prostate eight years after his attendance at the hospital, and one of stroke.

The most difficult cases to diagnose are those giving few symptoms other than the hematuria, which has ceased by the time the patient reaches the hospital. Cases of unexplained hematuria fall into several different categories, the prognosis is good if nothing abnormal can be found on full urologic investigation.

Several graphs and charts accompany this rather interesting statistical article.

DAVIS H. PARDOLL, M. D.

## THE KIDNEY

Destroying the Kidney Function by Roentgen Rays. Ernst Navratil. *Strahlentherapie*, 1933, XLVII, 348-358.

Klein suggested the treatment of cases with fistula of the ureter by roentgen irradiation of the kidney, in sufficient doses to destroy the function. Navratil tried this in a number of cases, one received 240 per cent H.E.D. during 3 weeks, the second case 240 per cent H.E.D. in 2 series, a third case 160 per cent H.E.D. in 7 weeks, a fourth case 100 per cent H.E.D. in 18 days, and a fifth case 130 per cent H.E.D. within one week. In not a single instance was the treatment successful. Three kidneys could be examined histologically after removal, no changes could be found which might be attributed to the roentgen exposure.

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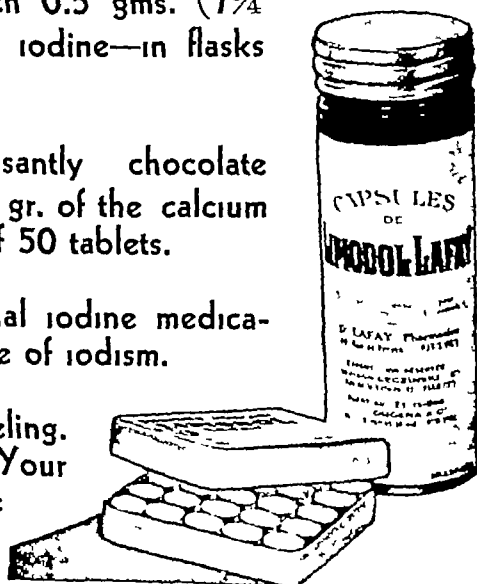
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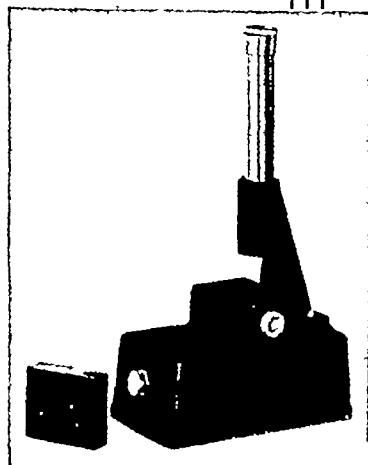


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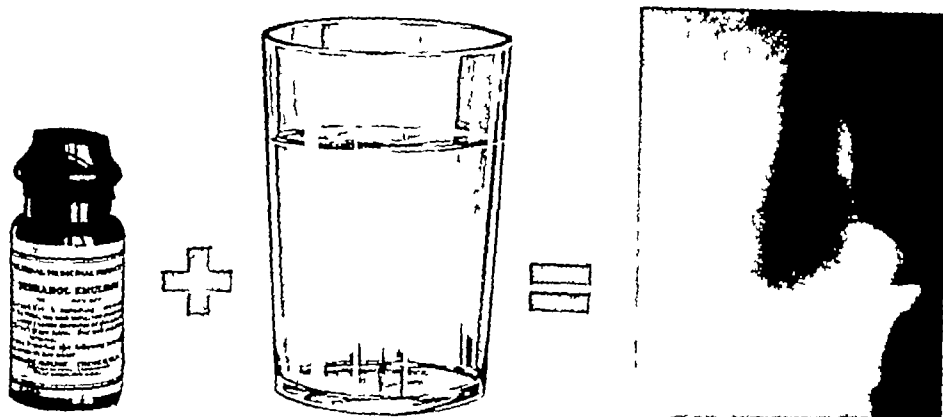


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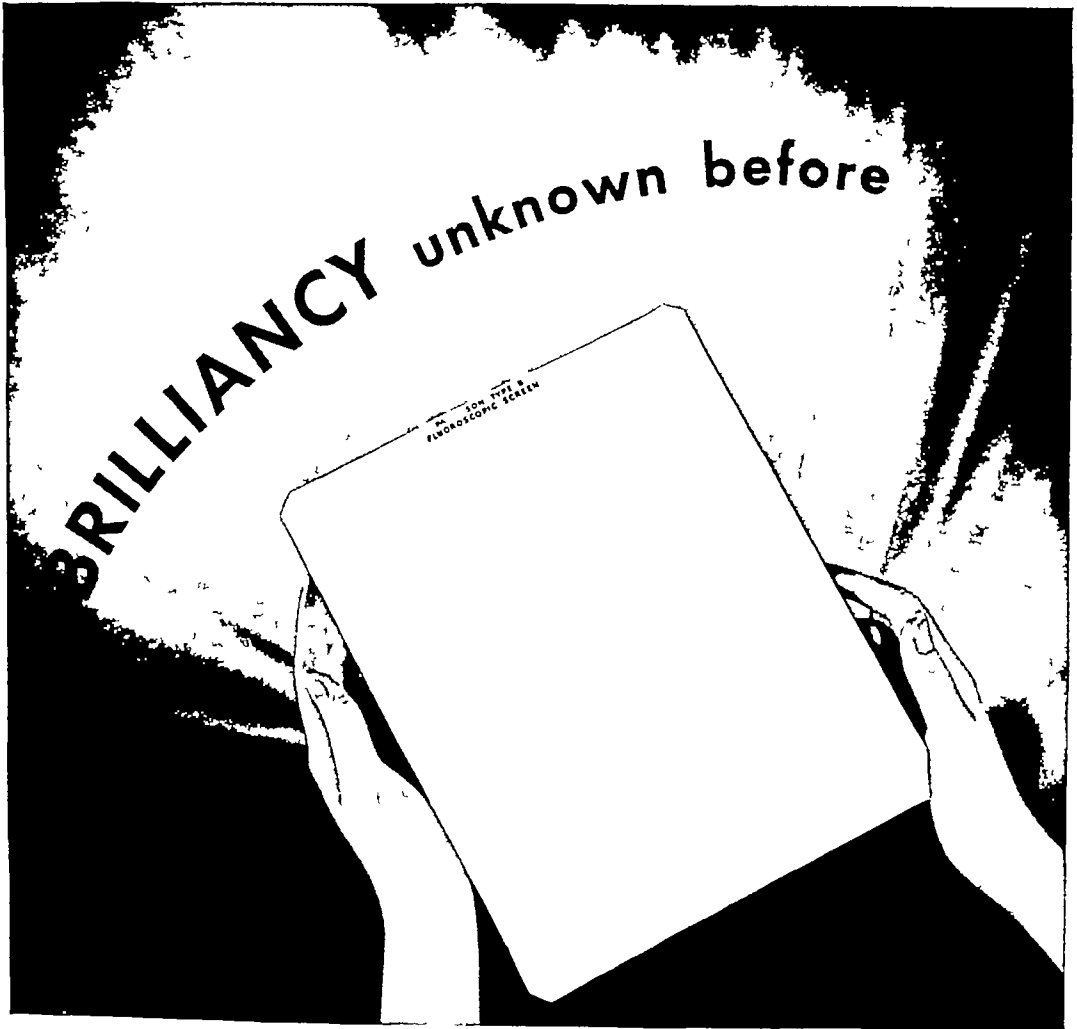
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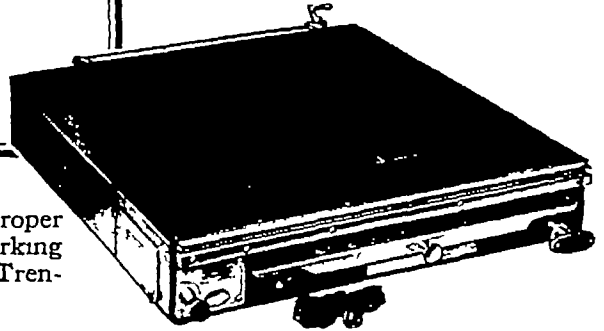
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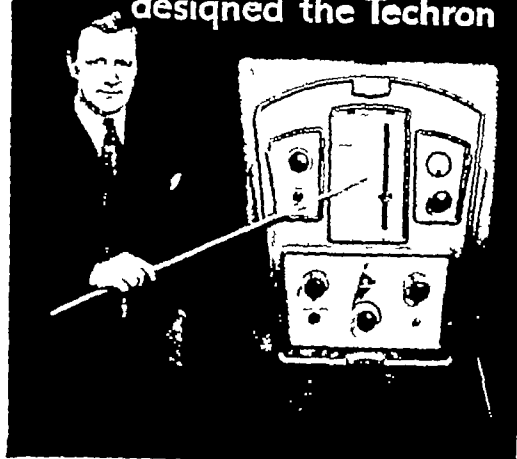
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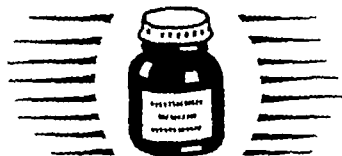
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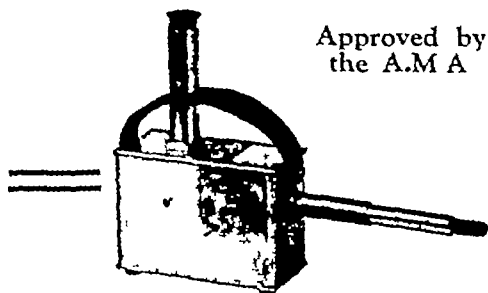
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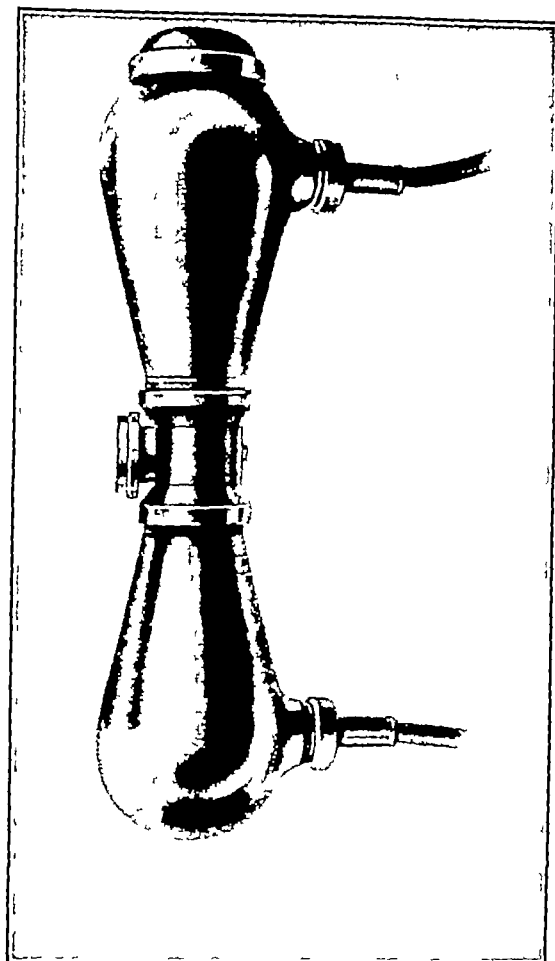
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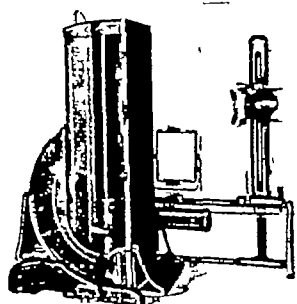
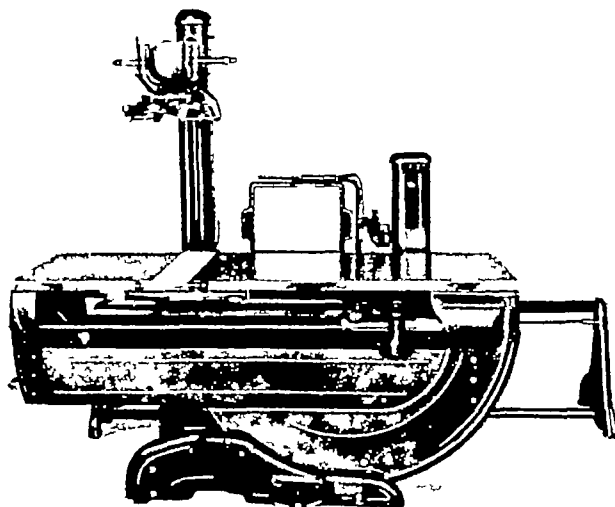
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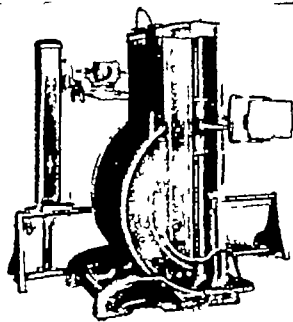


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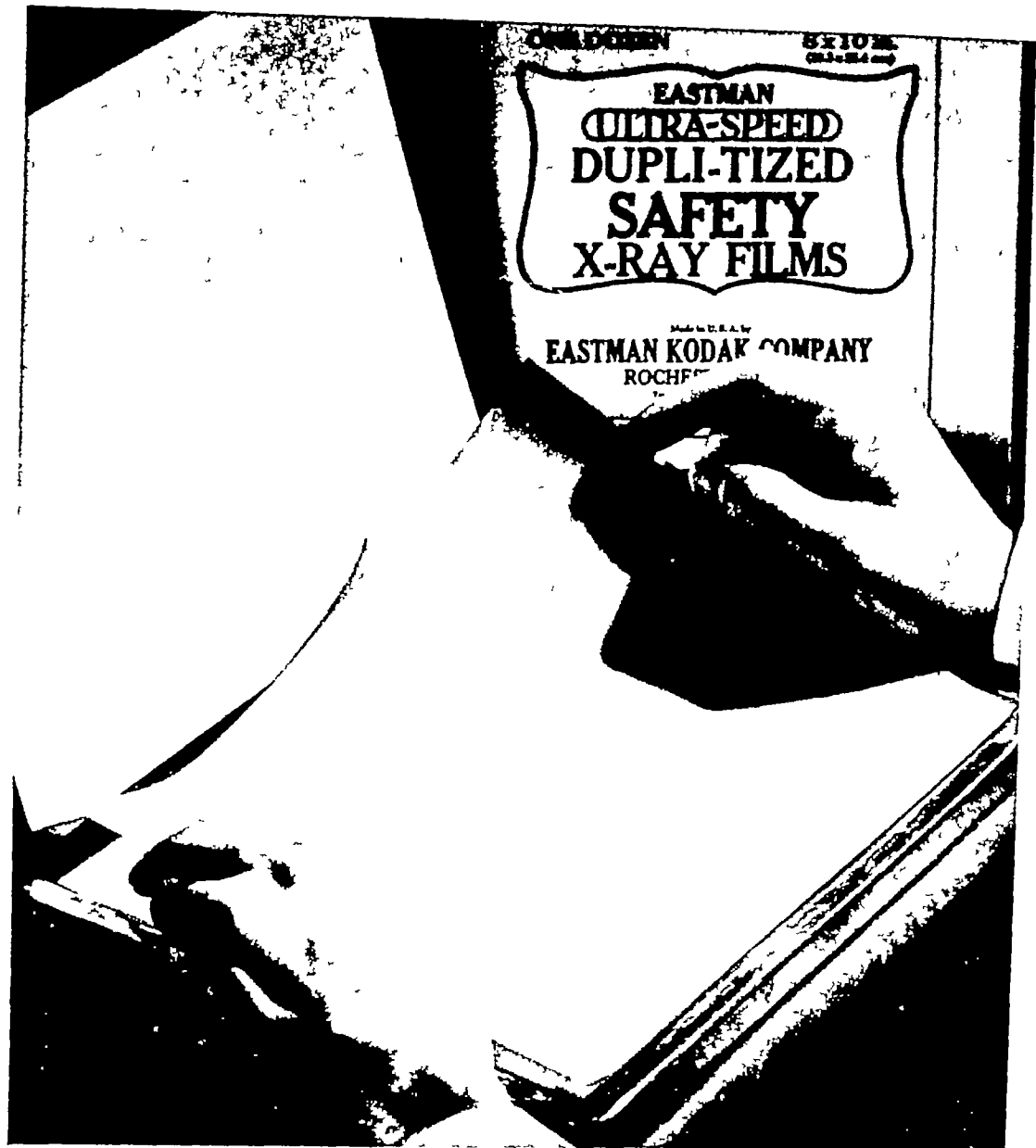
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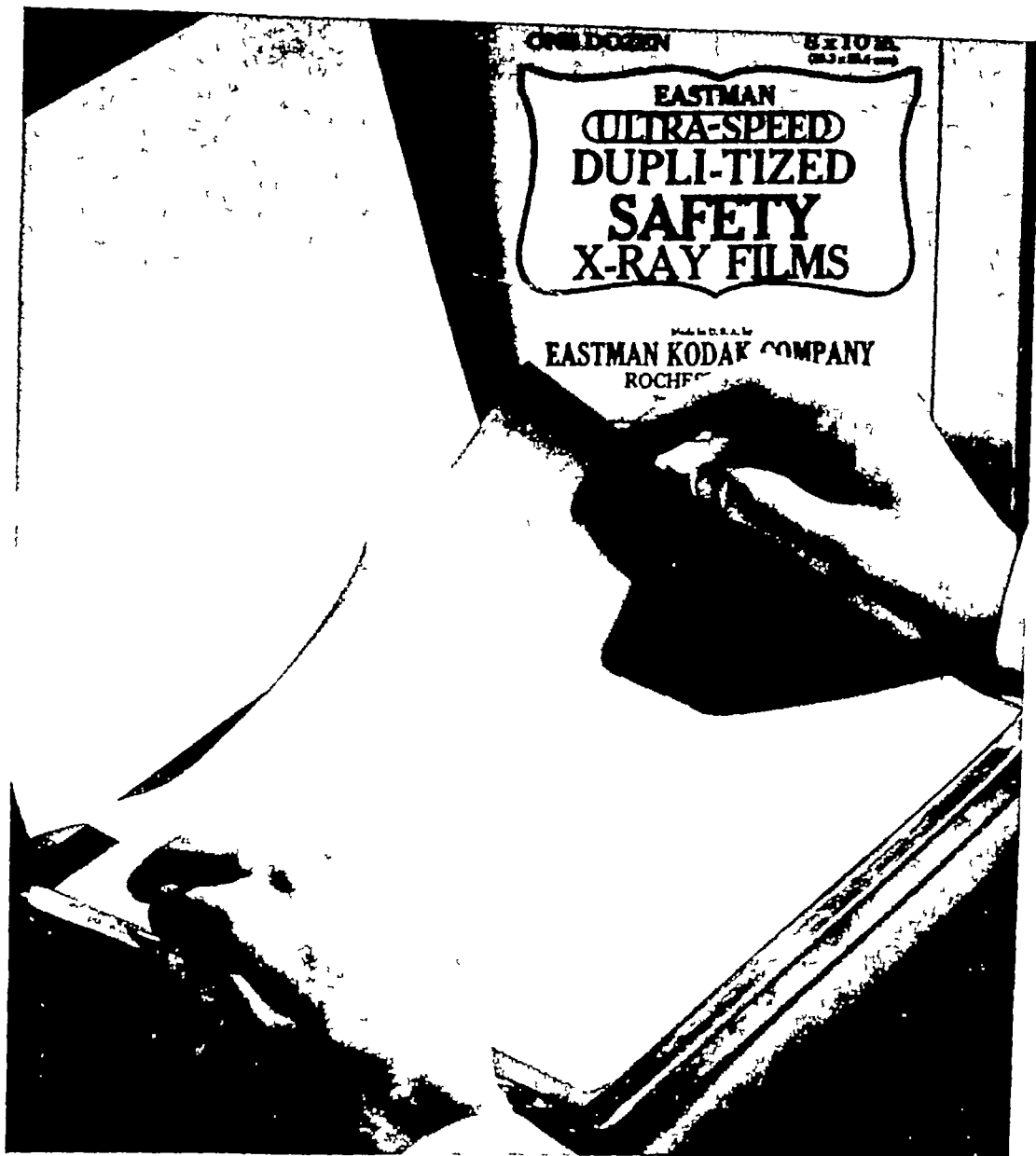
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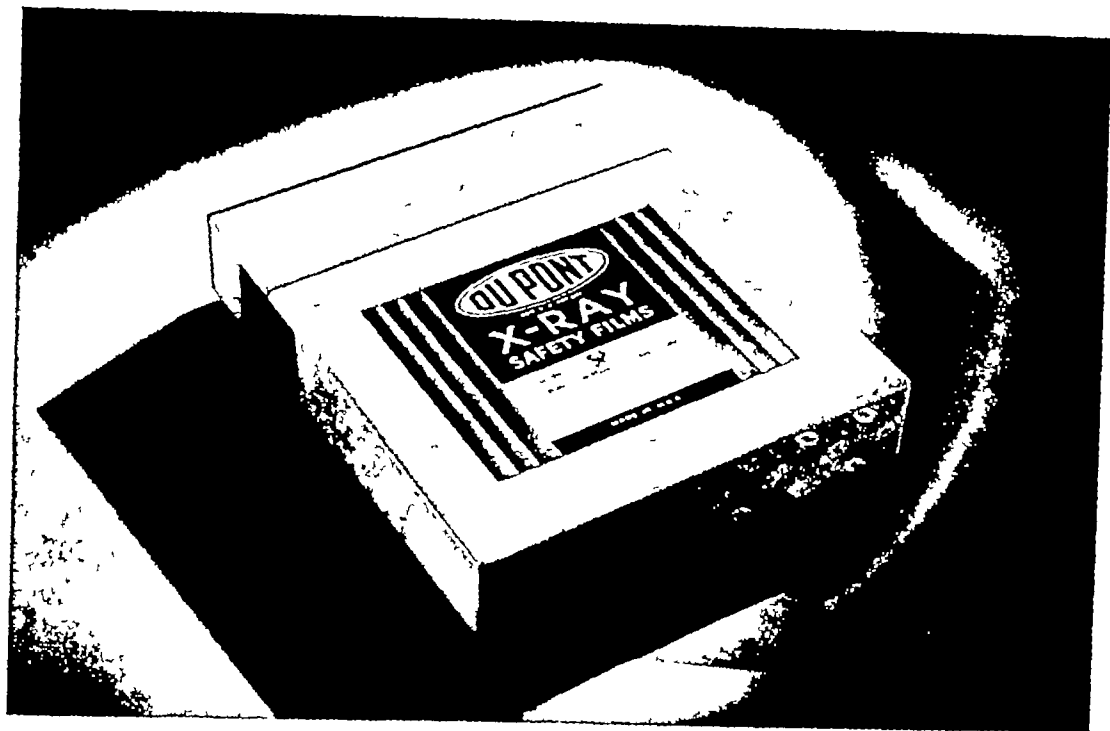
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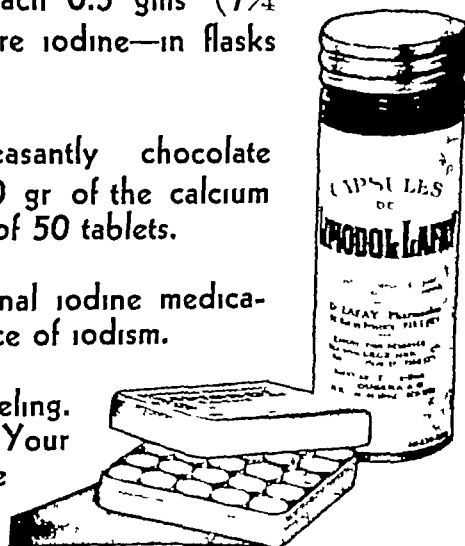
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# RADIOLOGY

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## THE ROENTGEN RAY AS AN AID IN THE DIAGNOSIS OF DISEASE OF THE NASAL ACCESSORY SINUSES<sup>1</sup>

By JOSEPH C BELL, M D , *Louisville, Kentucky*

THIS paper is not presented with the idea that it introduces anything new either in technic or interpretation. The technic used is a combination of well-known methods which, in my work, has proven satisfactory in the study of sinus

disorders. The purpose of this paper is to aid the radiologist in treating diseases of the accessory sinuses if they are properly interpreted. Satisfactory results can be obtained only through painstaking effort and by the use of proper equipment and technic. Interpretation requires a thorough knowledge

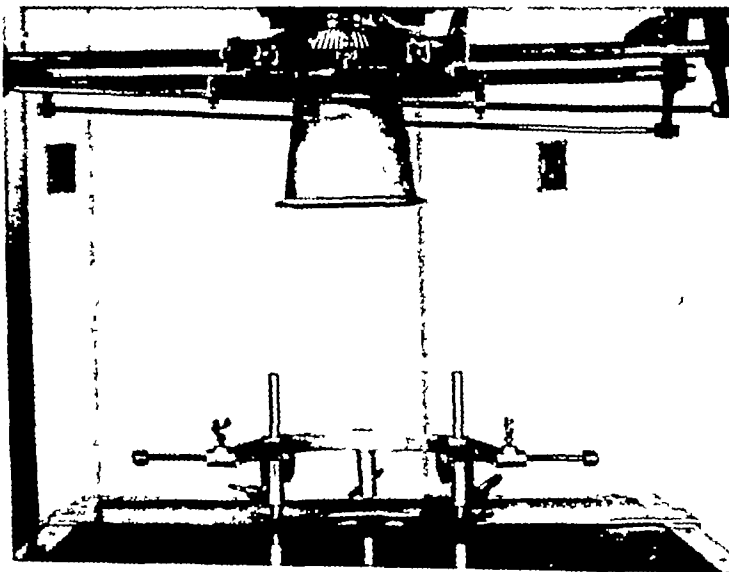
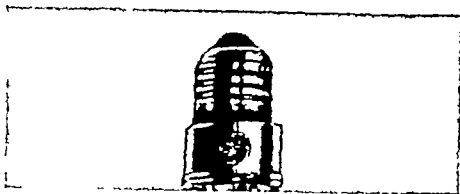


Fig. 1 Head clamp in place on table Tube centered over center of Bucky diaphragm

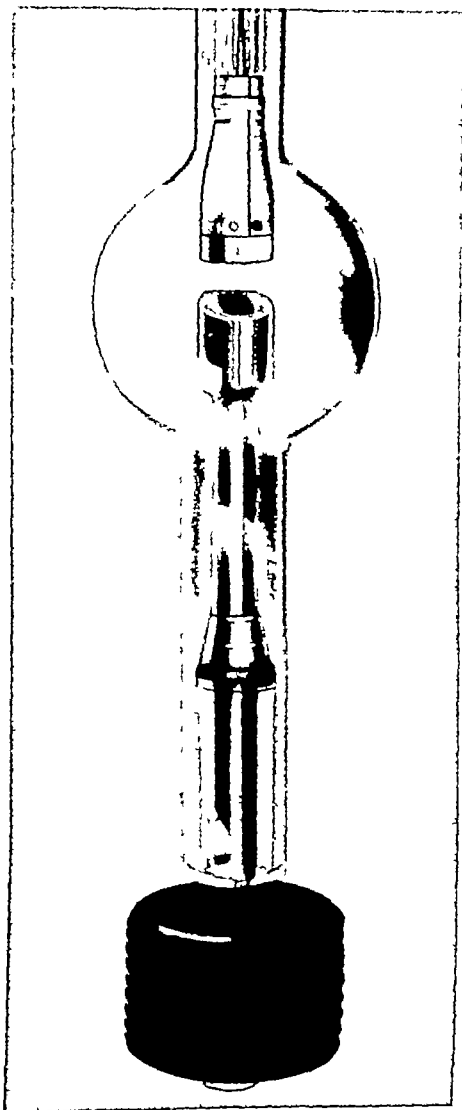
disease. The roentgenologic findings may be of the greatest help to the physi-

<sup>1</sup>Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28-Dec. 1, 1932.

cian treating diseases of the accessory sinuses if they are properly interpreted. Experience plays an important part in interpretation, providing it carries with it




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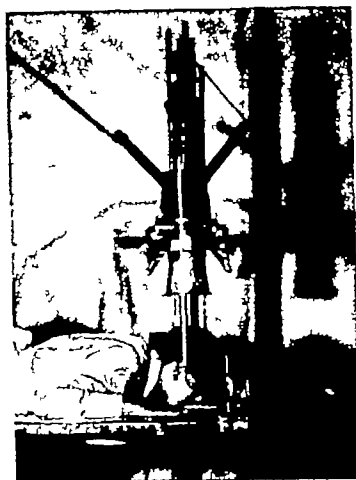


Fig 4 Position No 3 First stereoscopic position for antra



Fig 5 Position No 4 Second stereoscopic position for antra

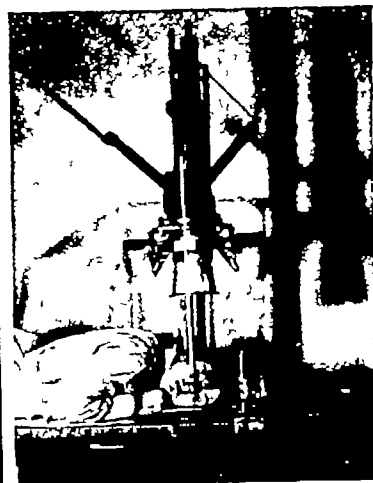


Fig 6 Position No 5 Lateral

diaphragm and center the tube in the same place

In the second position, that described by Granger, the clamp permits exact centering, while the pointer permits the direction of the central beam on a line parallel to one passing through the tragus. The Bucky diaphragm is used routinely.

The third position is essentially the Waters, and is the only one in which stereoscopic films are used routinely. It is my opinion that this is a most satisfactory position for visualizing the antra and that stereoscopic films add greatly to the accuracy of interpretation. As indicated, the tube is centered immediately over the anterior margins of the antra, and the first exposure made. The tube is then shifted toward the vertex, a distance of 2.5 inches, and the second exposure made. The tube is tilted only if the cone is small and there is danger of cutting off a part of the area that should be shown.

The fourth position is the lateral. In my experience it has little value in showing disease of the sinuses, but it does, to some extent, show the type of sinus development and may reveal easily demonstrable intracranial pathology, especially in the region of the sella turcica.

As stated above, these are the positions

used routinely but certain types of abnormalities may require additional films made with the special purpose of demonstrating more satisfactorily the lesion present. The axial, or vertex submental, position is of definite value in disease of the sphenoids and posterior ethmoids and re-

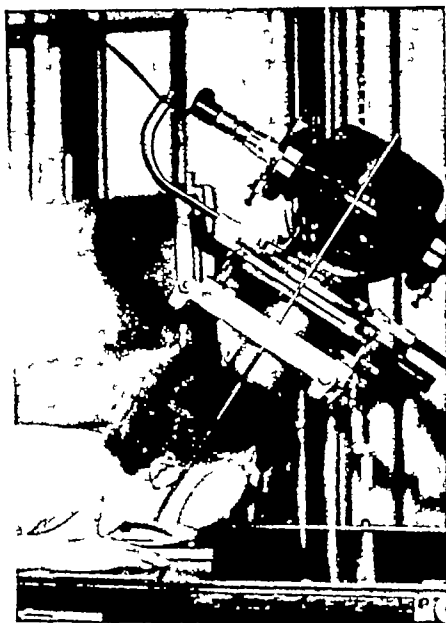


Fig 7 Position No 6 Vertex submental position for visualizing posterior ethmoids and sphenoids

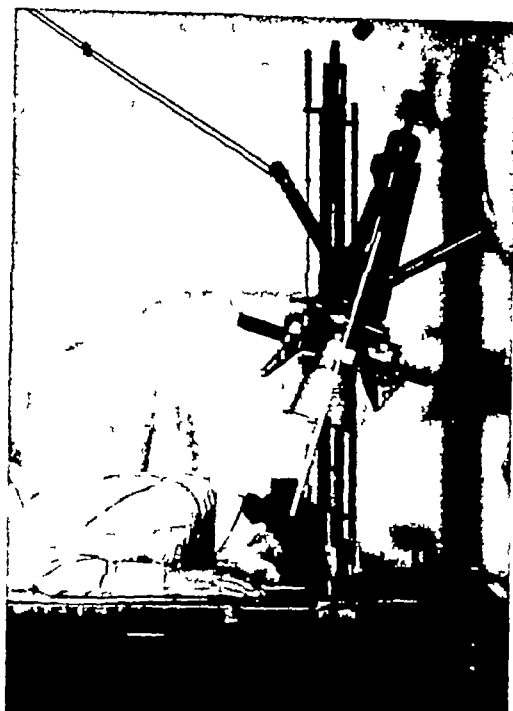


Fig 2 Position No 1 Visualization of frontal sinuses and anterior ethmoid cells Tube inclined  $17^{\circ}$  from the perpendicular

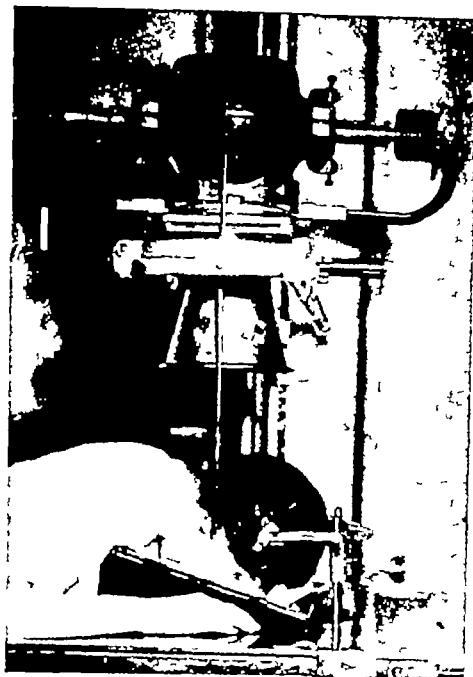


Fig 3 Position No 2 Granger position,  $17^{\circ}$  angle, Bucky diaphragm used

diligent study, a reasonable basic knowledge, and careful observation of the conditions found at the operating table

#### TECHNIC

The first essential is securing of technically satisfactory films, adequate in number, and made in such positions that each sinus is shown clearly with the fewest possible superimposed shadows. There are many factors which are most important if this first requirement is to be satisfied, one of the most important and an often neglected one being dark room technic. The proper dark room procedures are too well known to require repetition, but if results are to be satisfactory utmost care must be given these details.

Positions are an important consideration and the accompanying illustrations serve to show the ones used in my practice. The head clamp was designed by the writer and has two important pur-

poses. First, that exact centering of the head in relationship to the X-ray tube and the center of the film may be easily secured, and the second, adequate fixation. Many sinus films are misleading because rotation results in apparent increase in density of some of the areas because of superimposed shadows. This clamp is simple in construction and has proven to be most valuable, not only in sinus examinations but in all examinations of the head, including encephalograms and ventriculograms.

The first position used, designated as No 1, has for its purpose the visualization of the frontals and the anterior ethmoids. In this particular illustration the forehead and nose are down and the tube inclined 17 degrees toward the feet. The central beam is directed toward the base of the nose, a centering which is accomplished by the clamp and the pointer. In this position the above named sinuses are clearly shown. In many of my examinations, however, I use a 17-degree angle block without the Bucky

Infections in these sinuses frequently accompany those of the posterior ethmoids on the same side, explained by the close relationship of their openings into the nasal passage

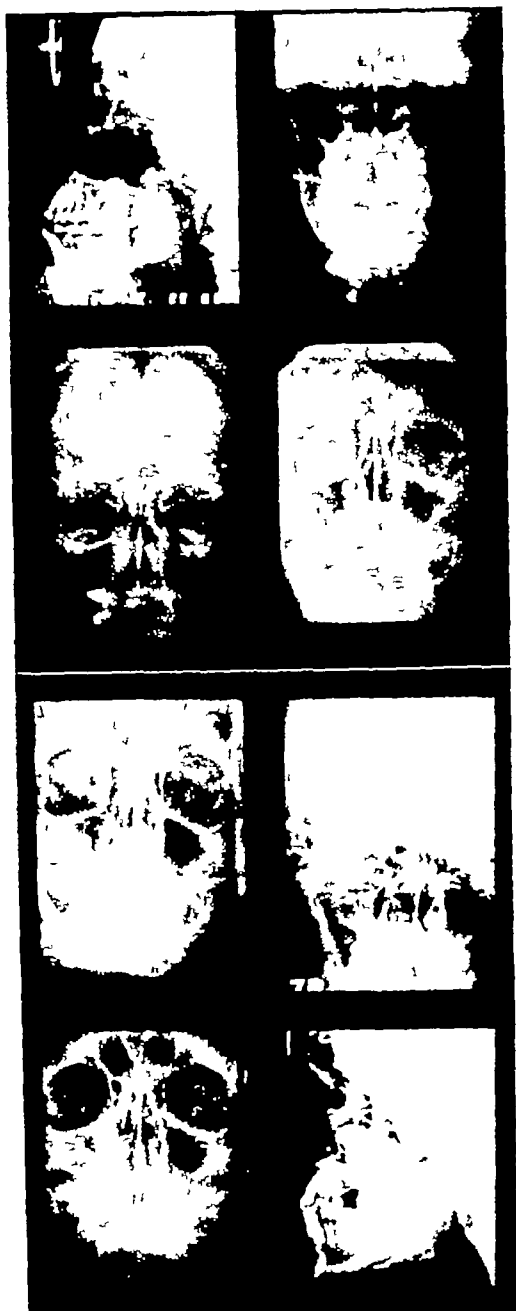
#### THE ETHMOIDS

Either group of ethmoid cells may show acute or chronic changes similar to those of the sphenoids. Hyperplastic changes in the mucosa are common, as are polyps. Infections of the anterior cells often accompany infections of the antra and frontals.

In the x-ray film, disease is manifest by an increase in the density of the sinus area. In acute disease this increase is

Fig 18 (*upper 4 views*) Case 6. Purulent infection of left sphenoid. Patient complained of pain in region of left eye radiating to the occipital area during a period of one year. The pain was more severe in the morning and less troublesome in the afternoon. Transillumination and other clinical examinations were entirely negative. The left antrum was irrigated and fluid returned clear. The left sphenopalatine ganglion was cocainized with some relief. X-ray examination showed definite clouding of the left sphenoid and no evidence of involvement of any of the other sinuses. A diagnosis of a left sphenoid sinusitis was made. This sinus was irrigated through the natural opening and a cast of pus approximately six inches in length was washed out. The diameter of the cast was exactly that of the opening into the sinus. Irrigations were repeated upon three occasions until the fluid returned clear. The patient has had complete relief from symptoms since that time.

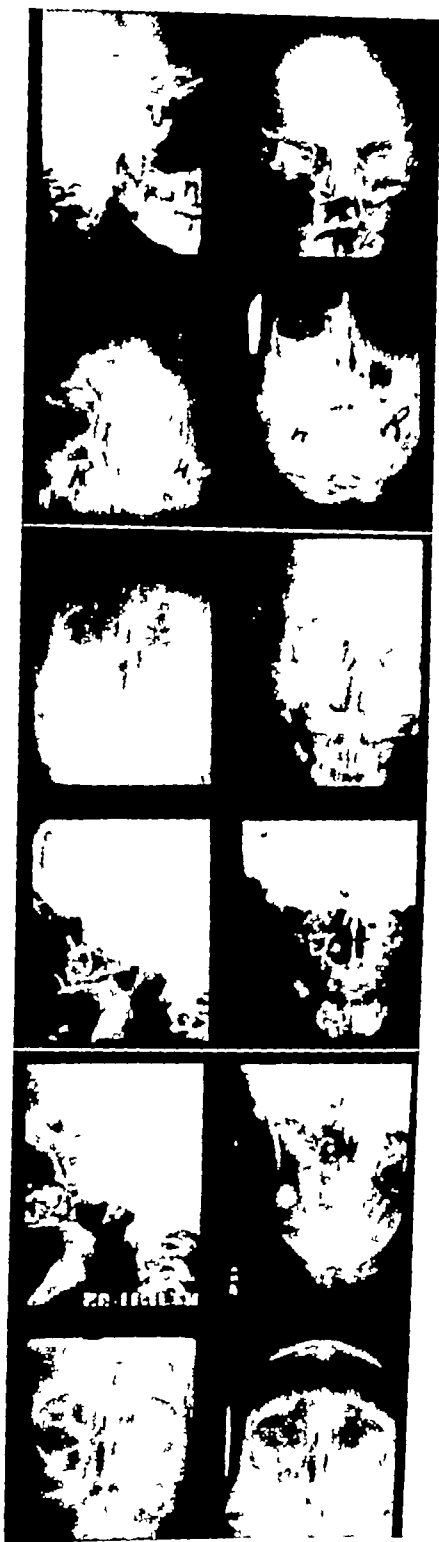
Fig 19 (*lower 4 views*) Case 7. Extensive mucosal thickening and polypoid degeneration, right antrum. Routine films and others after lipiodol injection. Patient experienced an attack of pain in the region of the right eye radiating to the right occiput, in October, 1930. At that time the sphenopalatine ganglion was cocainized and a refraction error in the eye was corrected. This resulted in relief. After a short period however, the patient again began to experience pain in the right antrum. In February, 1932, this became acute for a period of one week. At that time pus was washed out of the right antrum. X-ray examination was done March 7 and I reported evidence of very extensive hyperplastic changes in the mucosa lining the antrum. I also stated that there probably had been an infection of the ethmoid cells and right sphenoid at some time. There was no evidence of pus in the sphenoid at the time of the examination. Lipiodol injection confirmed the opinion that there were very extensive hypertrophic changes in the mucosa lining the right antrum and it was further stated that numerous polyps probably were present. A Caldwell-Luc operation was done upon the right antrum. The operation revealed very marked, firm thickening of the mucosa of the antrum, with extensive fibrosis and degeneration. A microscopic examination of the tissue removed from the antrum was reported by a pathologist as chronic inflammation, mucosal degeneration, fibroid polypoid. This patient has been entirely free from symptoms since the operation.



Figs 18 and 19

homogeneous but in hyperplastic disease there may be increase in the density of the walls of the cells, together with a lack of definition. In some instances the changes may be osteolytic in nature and the cell walls may be less dense than normal or may largely disappear.





Figs 15, 16, and 17

same side, explained by the very close relationship of their areas of drainage into the nose

#### THE SPHENOID SINUSES

These sinuses vary greatly in size and sometimes are seen as a single cavity, due to a partial or complete absence of the septum. This variation is important because it frequently explains the fact that the entire sphenoidal area shows evidence of infection in cases in which, otherwise, changes are limited to the sinuses of one side only. Drainage is at the upper anterior margin and as a result is not satisfactory in all positions. An acute purulent infection results in generalized increase in density of the sinus area. Resolution may take place or the disease may become chronic, with resultant hyperplastic changes in the mucosa. By the use of the x-ray it is possible to differentiate between a purulent and a hyperplastic sinusitis. In purulent disease the area beneath the roof is increased in density and the dependent margin of the roof cannot be seen, while in hyperplastic disease the roof may be broad and dense and the dependent margin lack definition.

Granger's excellent work has been most important in the demonstration and interpretation of the various abnormalities of these sinuses

Fig 15 (*upper 4 views*) Case 4 Acute infection of left frontal ethmoid cells and antrum. Anterior ethmoid cells obliterated. Child acutely ill apparently on verge of uremia. Very rapid recovery after drainage of infected sinuses.

Fig 16 (*middle 4 views*) (routine examination) and Fig 17, (*lower 4 views*) (examination after lipiodol injection). History of an acute sinus infection of 3 weeks' duration (Case 5). Pain in region of left cheek for 10 days. Inspection showed large amount of pus in middle fossa. Antrum was irrigated and much pus was obtained. X ray examination showed marked clouding of left antrum, left anterior and posterior ethmoids, the entire sphenoid area and the left frontal. The clouding of the entire sphenoid area was attributed to the fact that the septum was probably absent. Films made after injection of lipiodol into the left antrum showed a very marked irregular thickening of the mucosa, likely with polypoid degeneration. An opinion was expressed that this was probably an acute infection superimposed upon a chronic one. After 10 days of conservative treatment the acute infection had largely subsided. Radical operation was not done.

Infections in these sinuses frequently accompany those of the posterior ethmoids on the same side, explained by the close relationship of their openings into the nasal passage

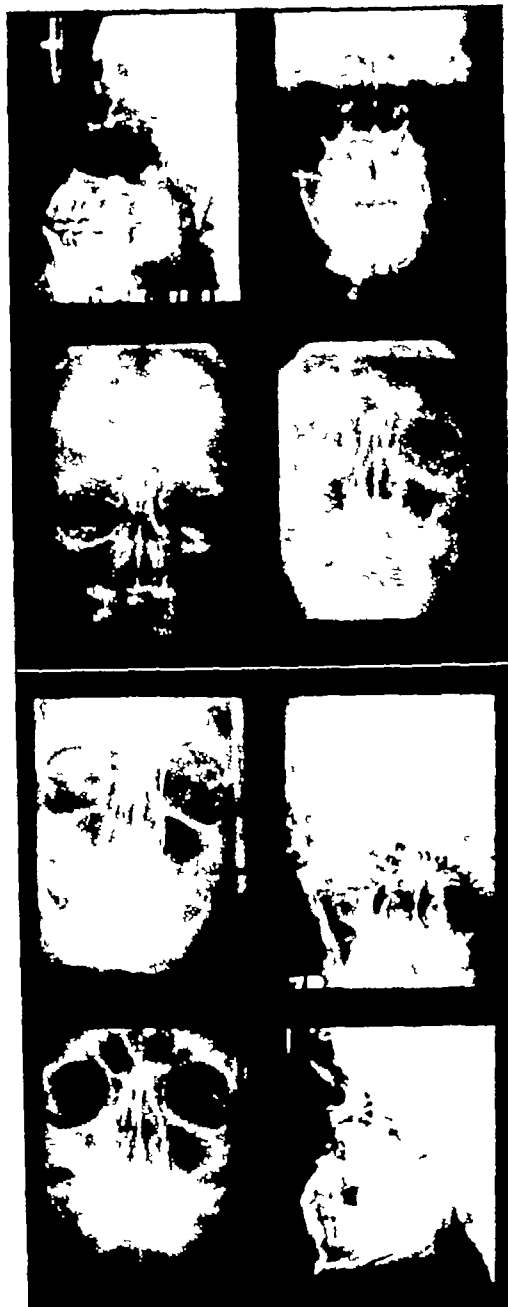
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Fig 19 (*lower 4 views*) Case 7. Extensive mucosal thickening and polypoid degeneration, right antrum. Routine films and others after lipiodol injection. Patient experienced an attack of pain in the region of the right eye radiating to the right occiput, in October, 1930. At that time the sphenopalatine ganglion was cocaineized and a refraction error in the eye was corrected. This resulted in relief. After a short period however, the patient again began to experience pain in the right antrum. In February, 1932, this became acute for a period of one week. At that time pus was washed out of the right antrum. X-ray examination was done March 7 and I reported evidence of very extensive hyperplastic changes in the mucosa lining the antrum. I also stated that there probably had been an infection of the ethmoid cells and right sphenoid at some time. There was no evidence of pus in the sphenoid at the time of the examination. Lipiodol injection confirmed the opinion that there were very extensive hypertrophic changes in the mucosa lining the right antrum and it was further stated that numerous polyps probably were present. A Caldwell-Luc operation was done upon the right antrum. The operation revealed very marked firm thickening of the mucosa of the antrum, with extensive fibrosis and degeneration. A microscopic examination of the tissue removed from the antrum was reported by a pathologist as chronic inflammation, mucosal degeneration, fibroid polypoidosis. This patient has been entirely free from symptoms since the operation.



Figs 18 and 19

homogeneous but in hyperplastic disease there may be increase in the density of the walls of the cells, together with a lack of definition. In some instances the changes may be osteolytic in nature and the cell walls may be less dense than normal or may largely disappear.



Fig 20 (left) Case 7 Hyperplastic tissue removed from antrum

Fig 21 (right) Case 8 Hyperplastic tissue removed from antra

### THE ANTRA

In acute infectious disease there usually is a homogeneous increase in the density of the antrum involved, due to swelling of the mucosa, the presence of pus, or both. If the mucosa is swollen, the inner margin of the thickened mucosa can usually be seen and it is likely to be regular and defined with fair sharpness. This is usually true also of allergic swelling without infection.

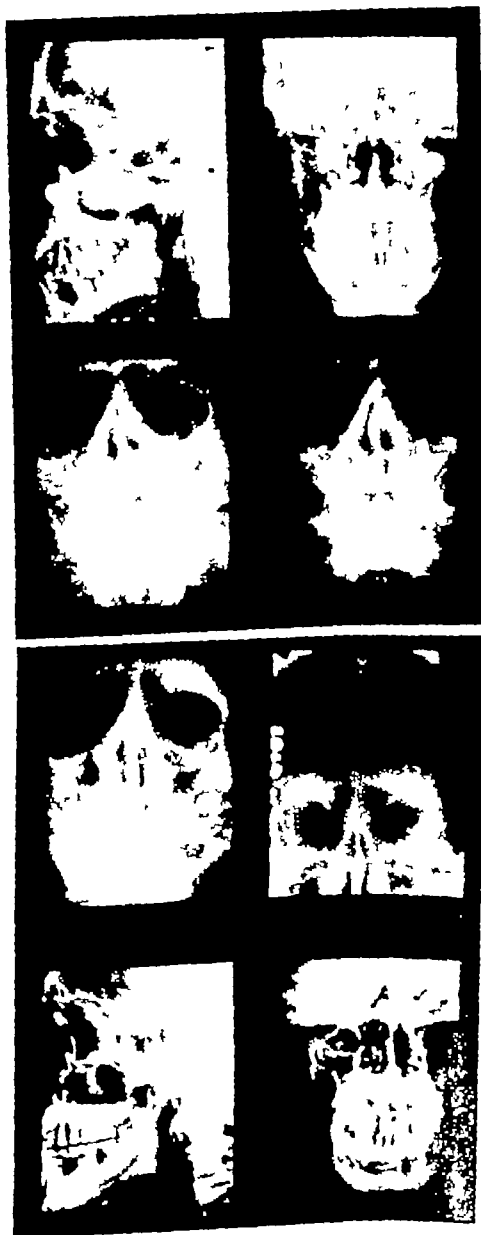
Drainage of the antra is not very satisfactory because the openings into the nose are at the upper medial aspects, and because of this, at least partly, chronic changes are common. These usually are manifest by hyperplasia of the mucosa, often followed by polypoid degeneration.

Fig 22 (upper 4 views) Case 8 Routine films

Fig 23 (lower 4 views) Case 8 Films made after lipiodol injection. Patient experienced acute attack of pain in left side of head 13 years ago. Had a similar attack 9 months later. These attacks recurred at intervals of about two or three months after that time. Polyps were removed from the nose two years ago. Others have been removed at intervals since, pain continued at intervals. Nasal examination showed polyps in the middle meatuses. Transillumination was essentially negative. Irrigation showed some old pus in the antrum.

X-ray examination (Oct 7 1932) showed evidence of extensive hyperplastic changes in the mucosa lining both the antra together with evidence of changes resulting from infection in the ethmoids and sphenoids. Lipiodol injection was done and the films showed a large irregular filling defect in the floor of the right antrum considered to be characteristic of changes resulting from hypertrophy of the mucosa together with polyps. Similar but less extensive changes were noted on the left. A bilateral Caldwell-Luc operation was done and marked hypertrophic changes in the mucosa of the antra, with polypoid degeneration were found. Intranasal operations were done on the ethmoids and sphenoids and changes similar to those in the antra were found. The patient has been without symptoms since the operations.

In an x-ray film the hypertrophied mucosa is shown by a shadow extending inward from the bony wall of the antrum. In a chronic active infection the inner margin of this shadow is likely to be irregular and indefinitely defined, but in cases in which the shadows are due to an old fibrosed mucosa the margins are dense and



Figs 22 and 23

sharply defined Polyps are seen as irregular shadows of varying sizes projecting inward from the margins and are found in any part of the antrum, especially the floor and lateral aspect An antrum filled with pus as a result of chronic disease cannot be differentiated from an

Fig 24 (*upper 4 views*) Case 9 Recurrent sinusitis of right antrum after radical operation, apparently reinfecting by drainage from right ethmoids and frontal This patient had first symptoms of sinus disease in 1928, at 14 years of age Onset took place after swimming, being characterized by pain over right eye Examination at that time showed infection of the right antrum, right anterior ethmoid cells, and right frontal, confirmed by x-ray examination and transillumination Symptoms subsided in ten days There was a recurrent attack nine months later, at which time the antrum seemed chiefly to be involved An intranasal window was made into the right antrum in June 1929 This window closed rather promptly and the patient had a recurrence of symptoms in December, 1929 In July, 1930, a Caldwell-Luc operation was done upon the right antrum In November, 1930, a reinfection took place in the right antrum and at that time purulent drainage was found coming from the right anterior ethmoid cells and the right frontal In February, 1931 a very large window was made into the antrum and a rubber drain was left in place for five days Improvement followed, but in February 1932, the patient began to have symptoms again In June, 1932, an x-ray examination showed some increase in the density of the right frontal and the right anterior ethmoid area There was very marked increase in the density of the right antrum and at that time an opinion was expressed that the increased density of the antrum was evidently the result of a longstanding infection probably with marked thickening of the mucosa and polypoid degeneration In July of this year a Caldwell-Luc operation was done on the right The anterior wall of the antrum was found to have regenerated after previous operations The mucosa was found to be greatly thickened and polypoid degeneration was present July 19 a Lynch external ethmoidfrontal operation was done Evidence of chronic inflammation was noted in the mucosa lining the frontal sinus and hyperplastic changes together with polyps, were found in the ethmoids This patient has been free from symptoms since the last operation

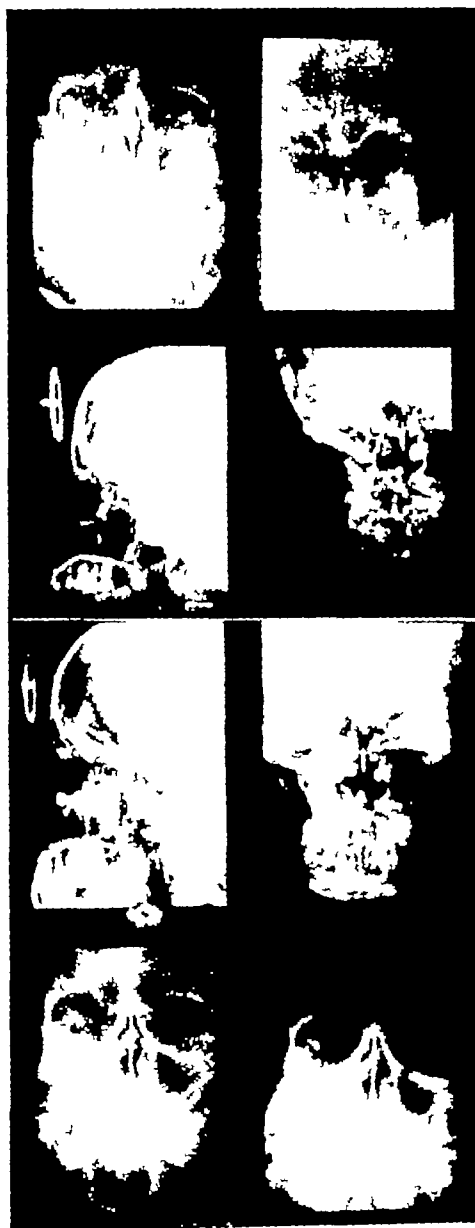
Fig 25 (*lower 4 views*) Case 10 Anterior filling defect due to polyps and hyperplastic changes in mucosa Patient experienced pain in region of right cheek, radiating over right eye, more or less constantly for a period of one year, aggravated by colds Examination of the nose was essentially negative The right antrum was irrigated and the fluid returned clear Transillumination was negative The routine films showed evidence of very slight thickening of the mucosa in the right antrum Lipiodol injection was then done Films made in the postero-anterior position were essentially negative However, stereoscopic films were made in the right lateral position and they showed a large filling defect in the anterior inferior aspect of the right antrum evidently the result of extensive hypertrophic changes in the mucosa Operation revealed a large polyp extending out from the anterior and inferior portions of the wall of the right antrum The mucosa lining this portion of the antrum was hyperplastic but was limited to this region The patient has had complete relief since operation which was done more than a year ago



Figs 24 and 25

acute infection and is usually not associated with extensive changes in the mucosa

Maxillary cysts may resemble polyps, making it difficult to determine their true nature without the use of an opaque medium and a dental examination The so-



Figs. 26 and 27

Fig. 26 (upper 4 views) Case 11. Marked increase in density of right antrum. Curved upper margin indicative of large polyp.

Fig. 27 (lower 4 views) Case 11. Filling defect after lipiodol injection. Operation revealed large polyp growing from anterior inferior wall. Hyperplasia of the mucosa limited to that area.

called follicular cysts may have teeth in them which will aid in the diagnosis.

The antra may vary in size and the difference in density may be misleading unless films are made stereoscopically.

#### GENERAL CONSIDERATIONS

Tumors—benign or malignant—may involve any of the above sinuses. They may be mistaken for changes resulting from infection. In malignant tumors, bone destruction suggests the true nature. Traumatic disturbances may involve the sinuses, the walls may be fractured, there may be hemorrhage into the sinuses and often secondary infection follows. Infections of any of these sinuses may extend into the surrounding bony walls, an osteomyelitis may result, and an infected sinus may rupture into any of the surrounding areas.

Sinusitis is a frequent complication of many acute infectious diseases, especially influenza, scarlet fever, and measles. The incidence is high in pulmonary tuberculosis and it may be a serious complication in diabetes. True tuberculous and syphilitic infections of the sinuses take place but are relatively rare. Sinusitis is found frequently in the presence of bronchiectasis, certainly aggravating the condition in the chest, and it may well be a causative factor in the onset of the disease.

#### THE ROENTGENOLOGIST'S REPORT

This report should include a description of the conditions noted in each sinus, including variations in size and in the thickness of the walls. The latter is especially important in the antra, for variations in size and thickness may add to the difficulty of operation unless they are recognized. The report should give a detailed interpretation of the significance of the various findings and should state what abnormalities are thought to be present. If this is done, the roentgenologist will render a real service to the physician referring the case and will be accorded his proper place as a consultant.

#### DISCUSSION

DR MORRIS E. NEWMAN (Buffalo, N. Y.)  
Although not a member of your Society but enjoying its privilege through the courtesy of one of your members, I should

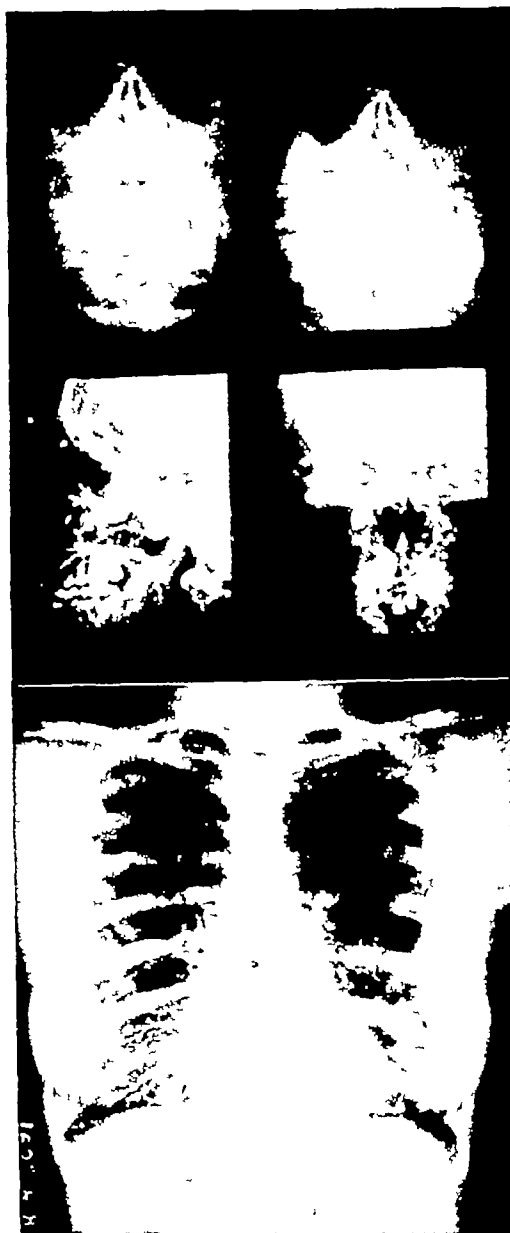
like the opportunity to say a few words on Dr Bell's paper from the angle of the otolaryngologist

I have been interested for a good many years in the relation of bronchiectasis and sinus infection, and it is my opinion that every case of bronchiectasis has or has had an ethmoid infection, and many cases have an associated infection in the maxillary antrum

Lipiodol injection is coming into more common use in diagnosis of chronic sinus disease I should like to question the speaker as to whether he instills the lipiodol himself or has it done by a nose and throat specialist—whether the antra are washed out prior to the instillation of the oil or whether the oil is put in through the normal antrum orifice I think the picture as seen following an antrum wash with lipiodol injection differs from the picture as seen in a case in which the oil has been injected into a sinus not previously irrigated

In reference to the question of transillumination by the rhinologist for diagnosis of sinus infection, I think we are getting farther away from forming our opinion on transillumination alone, especially in cases of thickened bone and old chronically thickened membranes, and are referring our cases to the x-ray specialist and depending more on his interpretation of the sinus plates, in conjunction with our clinical findings, and disregarding transillumination as an important adjunct

Fig 28 (*upper 4 views*) Case 12 Extensive hyperplastic sinusitis in patient with definite bilateral bronchiectasis Chest symptoms have almost entirely disappeared since radical operation on antra and intranasal operation on ethmoids



Figs 28 and 29

Fig 29 (*lower 4 views*) Case 12 Lipiodol injection showing cylindrical type of bronchiectasis in right lower lobe Condition is evidently bilateral

# LUCKENSCHÄDEL OF THE NEWBORN

By HOWARD P. DOUB, M.D., and JOSEPH T. DANZER, M.D., *Department of Radiology, Henry Ford Hospital, Detroit, Michigan*

**A**BOUT a year ago a newborn baby was referred to us for roentgen examination of the skull and spine. The clinician reported that the skull bones felt as if they could be molded slightly, and that there were soft spots present over the head. There was also an extensive spina bifida, with meningocele, present. Roentgen examination revealed numerous lacunæ, with bony ribs surrounding them, throughout the skull. There was also an extensive spina bifida present. On searching the literature no description of this syndrome could be found in English but it was adequately described in the German literature. Recently an excellent description of this anomaly was given by Kerr (8) in the "American Journal of Roentgenology and Radium Therapy."

Various names have been applied to this condition by authors writing on the subject. It has been called "relief skull," "lacuna skull," and "Luckenschädel." Throughout this communication we will use the term "Luckenschädel," as originally given by Engstler (2).

In 1875, James F. West (15) described a case of spina bifida, with meningocele, in the cervical area. Associated with the spinal condition were small defects which occurred throughout the vault of the skull. This is the first description of a case presenting associated defects in the skull and spinal column. A little later von Recklinghausen (14), in discussing spina bifida, described two cases which had associated skull defects, apparently examples of this condition. In 1903, Heubner (4) discussed the fact that in cases of spina bifida one frequently finds associated defects in the cranial bones and reported a case of spina bifida and club feet, with very marked skull changes. Perhaps the most complete article on the subject is one by Engstler (2), which appeared in 1905. He made

an extensive survey of the literature and collected 12 cases. The inclusion of some of these cases is questionable, however, owing to incomplete autopsy reports. He gave an excellent description of the condition and noted the association of the spinal and cranial defects. After studying Engstler's (2) cases, Wieland (16) decided that two different types of cases were represented in his report—one, the condition under discussion, and the other a simple apposition defect. One of the most complete studies of this condition was reported by Faust (3) in 1931. He described in great detail the gross and microscopic pathology represented, and also discussed thoroughly the various theories relating to the etiology.

The appearance of the skull does not show a characteristic deformity. There is a tendency in most cases, however, toward hydrocephalus, although skulls of normal appearance have been described and even two cases of microcephaly. Upon palpation the skull feels plastic, as though it could be easily molded with the hand, and there may be numerous small soft areas felt throughout the vault of the skull. The sutures may be widely separated. These cases of skull deformity have an associated spina bifida or encephalocele.

The roentgen film discloses an abnormal calcification of the bones of the vault of the skull, a calcification which occurs in the form of bony ribs which inclose sharply outlined, rounded or oval-shaped areas of radiolucency due to a lack of calcification. This gives the skull a honey-combed (Schinz, 11) or net-like appearance which is characteristic of the condition. These bony ribs are inclined to have a rather dense, eburnated appearance, accentuated by the areas of lessened density surrounding them. Associated with the skull changes

is found the typical appearance of spina bifida, with meningocele. Encephalocele may also be seen.

On postmortem examination the outer layer of the cranial bones is found to be smooth to the touch. The cranial defects are covered by a stout parchment-like membrane or a thin layer of bone. The inner table of the skull presents a different picture—a rough and irregular surface, with many interlacing beams of bone between which are round or oval depressions or lacunæ. These lacunæ measure from 0.5 to 2.5 centimeters in diameter and vary from a slight depression in the inner table to a complete penetration through the skull bone. Faust (3) made a comprehensive gross and microscopic study of the cranial bones of one of these cases and states that these bony beams are hard, thick, and rich in blood vessels.

There is a sharp disagreement among different authors in regard to the etiology of this condition, the most common theory being that of a pressure disturbance. This is supported by such writers as von Recklinghausen (14), Faust (3), Wieland (16), Schuller (12), Schinz (11), and others. Von Recklinghausen (14) believes that the condition may exist as the result of anatomical defects, but states that it may begin as a meningeal hydrops which produces an increased pressure of the spinal fluid and causes a herniation of the spinal canal. Faust (3) believes that there is increased intracranial pressure, and that the meningocele or encephalocele acts as a tension valve for the subarachnoid fluid. He believes that the cleft formation of the medullary tube is of primary importance and the malformation of the skull the result of this. Wieland (16) states that the circumscribed erosions are explained through the mechanical action of increased pressure. Because of the especially rapid growth of the brain at this age, the lateral portions of the skull arch are undeveloped and, therefore, the skull is more susceptible to the formation of defects at this time from the influence of increased pressure.



Fig. 1 (Case 1) Photograph showing meningocele

Engstler (2) opposes the theory that increased pressure is the etiologic factor in this condition. He believes that there is occlusion of the vertebral artery, with a consequent lessening of blood supply to the cranial bones, the latter condition interfering with their normal calcification. According to this author, it is a condition primarily of maldevelopment.

Colin (1) does not believe that these defects can be accounted for by mere mechanical pressure, but are the result of



delayed development or calcification of the cranial bones. He states that he has seen such deformities in infants who are otherwise normal.

The roentgen appearance of Lucken-

however, and soon changes to normal calcification. In 1921, Hughes (5) reported a series of cases which he called "craniotabes." He states that craniotabes, arising during the first few months of infancy,



Fig. 2 (Case 1) Bony ribs enclosing lacune. Typical appearance of Lückenschädel.

schädel is unlike the appearance seen in most other skull conditions. It must be differentiated from the soft skull apposition defect described in detail by Wieland (16), who states that the latter defect is due to the fact that during the last few months of pregnancy the brain grows so fast that the membranous portion of the skull is expanded and the calcification process is unable to keep pace with the rapid expansion of the skull. The baby is born with the edges of the skull bones uncalcified, showing soft skull apposition defects. This is a physiological process,

is only a fresh manifestation of fetal atrophy already existing in late fetal life. He attempts to differentiate fetal rickets, or craniotabes, from the soft skull defect of Wieland (16), but does not mention Luckenschädel. The appearance of the illustrations accompanying this article is such as to strongly suggest that they are cases of what we call Lückenschädel.

In this connection skull defects seen in Schuller-Christian's disease would have to be considered, but the clinical features of this disease are sufficient in themselves to make the differential diagnosis.

## CASE REPORTS

Case 1 W T R, white male, born Dec 16, 1932, vertex presentation, Wassermann negative. There was normal delivery, and the child cried promptly with weight, 4,050 grams, length 54 centimeters. Diameters of head: occipito-mental, 16 cm; occipito-frontal, 11.5 cm; occipito-Bregma, 10 cm; biparietal, 8.5 cm; bitemporal, 8.5 cm; suboccipito-Bregma circumference, 34 centimeters. At birth it was noted that the appearance of the face and forehead was similar to that of a Mongolian idiot. The spina bifida and skull abnormality were noted at that time. One other child of same parents is living and well.

Later examination disclosed a soft, easily molded skull which felt like parchment, and there were numerous soft places distributed over the head. There was a large spina bifida, apparently extending from the sacrum to the skull as no spinous processes could be felt, and there was a double line of bony ridges to either side of the mid-line. There was also a myelomeningocele in the lumbar area. There were bilateral club feet. The sphincter function was normal, there was a congenital heart lesion, and the general muscle tone was lowered. The child cried vigorously, with even the slightest movement of the head, suggesting that movement caused pain. The progress of the child was continuously downward and it expired Dec 29, 1932. Permission for an autopsy was refused.

Roentgen examination of the skull shortly after birth revealed that the lacunae were surrounded by the bony ribs which are so characteristic of Lückenschädel. There was also the accompanying spina bifida, with meningocele in the lumbar area. There was no bulging of the sutures.

Case 2 Stillborn white female, born May 9, 1924, breech presentation, Wassermann negative. Because of a marked hydrocephalus, which was diagnosed previous to delivery by means of x-ray exami-



Fig. 3 (Case 1) Anteroposterior projection of skull shown in Figure 2

nation, a catheter was inserted into the cranial cavity and 875 c c of cerebrospinal fluid was drawn off, after which the child was delivered spontaneously. A large spina bifida, with meningocele, was present in the dorsal region. Weight, 2,515 grams, length of body, 46 centimeters. Head measurements: occipito-mental, 17 cm; occipito-frontal, 15.5 cm; suboccipito-Bregma, 14 cm; biparietal, 13.5 cm; bitemporal, 8.75 cm; suboccipito-Bregma circumference, 44 cm; greatest circumference of head, 47 centimeters. One other child of the same parents is living and well at the age of five years.

The tissues were removed from the skeleton, which was kept as a museum specimen. Examination of this skeleton reveals a large hydrocephalus with multiple small rounded areas, in the frontal region, which are devoid of bone. These openings in the bone are covered by a stout parchment-

like membrane which shows no evidence of bulging. The bone surrounding these openings does not appear to be thicker than normal and does not show the rib-like formation usually seen in Lucken-

## DISCUSSION

One of the most interesting features of this condition is the question as to its etiology. There are many theories as to



Fig 4 (Case 2) Photograph of fetus showing hydrocephalus and meningocele



Fig 5 (Case 2) Photograph of dried skull of fetus showing hydrocephalus and bony defects in frontal areas

schadel. The spine shows an extensive spina bifida throughout and in the dorsal area there are marked congenital deformities of all the vertebrae, with corresponding deformities of the ribs.

Two years later the mother gave birth to another stillborn child which had an extremely large encephalocele.

the probable cause of its occurrence and, for the sake of convenience, we have classified them under the following headings: (1) The theory of pressure disturbance, (2) the theory of congenital growth disturbance, and (3) the theory of deformity due to disease.

The majority of the writers on this subject, as we have already mentioned, appear to favor some type of pressure theory. Some of the arguments advanced to support this theory appear to us as rather fanciful. It would seem that if pressure is to be considered as the main factor in the production of this deformity of the skull, it could best be explained by the action of internal hydrocephalus. It is a well known fact that in persons who have

increased intracranial pressure we see evidence of convolitional atrophy of the inner table of the skull. The skull bones of cases presenting increased intracranial pressure and those of Luckenschadel show somewhat similar characteristics inasmuch as both have irregularity of the surface contour of the inner table of the skull and a smooth outer surface. If this amount of bony change can be produced in an adult skull by increased pressure, it is easy to suppose that a much more marked change could be produced by pressure on incompletely formed skull bones undergoing calcification. Some support is given to this theory by our second case, reported above, which developed marked hydrocephalus *in utero* and which, while not presenting the typical bony changes seen in Luckenschadel, still shows similar bone defects in the frontal area. This case also showed extensive congenital deformity of the spine, with rachischisis.

It must be remembered that spina bifida, with an accompanying myelomeningocele or syringomyelocele, is always present with this skull deformity and that demonstrable hydrocephalus is present in a high percentage of the cases. It is a well-known fact that, if the sac of a myelomeningocele is removed in an attempt to repair this condition, the child will always develop a hydrocephalus. Penfield and Cone (10) have shown that if the sac is folded in, and not removed, when the operation is performed, hydrocephalus will not occur. The presence of hydrocephalus in a high percentage of these cases, together with myelomeningocele, would lend some weight to the theory that increased pressure does play some part in the etiology of this condition.

A number of writers favor the theory of a congenital growth disturbance. Cohn (1) believes there is a delay in the rate of calcification of the cranial bones, and he states that he has seen similar changes in otherwise normal infants. Von Recklinghausen (14) and Engstler (2) describe blood vessel changes resulting in lessened blood supply to the cranial bones, with

interference in their normal calcification. They believe these changes are fundamentally of a congenital nature.

It is well known that congenital deformities are exceedingly apt to be multiple in the same individual, just as we have here deformities of the skull, spine, and feet. An example of a similar multiple lesion which might be quoted is anencephaly, with skull and spine deformities, which has enough points of similarity to suggest a similar etiology.

The theory of a disease process being the causative factor in this condition should be mentioned. Hughes (5), in 1921, gave his conception of craniotabes. He believes that craniotabes of infancy is only a fresh manifestation of a state of fetal atrophy already existing in later fetal life. He quotes Wieland's (16) work but does not mention the term Luckenschadel. The illustrations accompanying Hughes' article appear to show changes identical with those seen in Luckenschadel, although he calls them "craniotabes." He states that craniotabes may be caused by either rickets or syphilis.

Syphilis has been mentioned by various writers as the causative factor in Luckenschadel, but in the reported cases, in which complete studies have been made, the Wassermann report of the mother has been negative. This evidence, although not conclusive, suggests that syphilis does not play a part in the etiology of this condition.

#### SUMMARY

I The syndrome of Luckenschadel, consisting of alterations of calcification of the skull bones, combined with meningocele or encephalocele, is described.

II A typical case of this syndrome is reported.

III The etiology is not known but the theory of fetal increased intracranial pressure seems the most plausible and has the largest number of supporters in the literature.

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Fig 4 (Case 2) Photograph of fetus showing hydrocephalus and meningocele

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Fig 5 (Case 2) Photograph of dried skull of fetus showing hydrocephalus and bony defects in frontal areas

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## AUTOMATIC TEMPERATURE REGULATION FOR THE X-RAY DARK ROOM SOLUTIONS

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From the Department of Radiology, Temple University Medical School

MANY x-ray dark rooms have no scientific method of control of the temperature of the solutions and wash tanks a few are not even equipped with thermometers So the question arises, "What difference does it make?" The answer to this question may be found in such works as that of R B Wilsey<sup>1</sup> He has shown that there is a range of exposure and development time giving the best radiograph, and that outside of this range the quality is distinctly inferior The degree of development depends not only upon the time that the film is in the developer, but also upon the temperature of the latter Thus a density reached by five-minute development at 65° F would also be reached by 6.9-minute development at 60°, 4-minute at 70°, 3-minute at 75°, and 2.2-minute at 80° Therefore, if uniform development is desired the temperature of the solution must be measured and the development time estimated from this If the temperature control is not automatic, constant attention must be paid to the details of development Uniform development results in a better quality of radiograph and also permits and encourages a more uniform exposure technic There are other reasons why development should be carried out at a temperature near 65° For example, the emulsion swells excessively in solutions that are too warm, and then becomes soft The swelling due to excessive temperature may give rise to a grainy appearance of the film and the softening makes the emulsion very susceptible to pressure and scratches The temperature of all of the solutions should be approximately the same or the emulsion may be damaged when the film is transferred from one tank to another Where

temperature control is not employed, the temperature of the wash tank is especially apt to be considerably different from that of the other solutions

A few different methods of temperature control are described below Installations for this purpose vary in size and cost, but each requires (1) a method of cooling, (2) a source of heat, and (3) an automatic switch with solenoid valves

*Method I*—Employing compressor with cooling coils, hot water coils, solenoid valves, and double throw Mercoid switch (Fig 1)

Water regulating the temperature of the solutions enters the dark room from a conditioning tank (Fig 1) This is a large tank of about a hundred gallons capacity containing two copper coils *A* and *B*, an inlet pipe at the top, and an outflow pipe extending down to the bottom The tank is surrounded by a good heat-insulating material such as cork or hair felt The copper coil *A* is made of tubing  $\frac{1}{2}$  inch inside diameter and about three hundred feet long, bent or wound in helical form The coil *B* is made of 200 feet of the same size tubing, wound in a similar manner<sup>2</sup> One of these coils, *A*, is connected to a refrigeration compressor *R*, run by a one horsepower motor *O* Methyl chloride from this compressor expands in this coil upon passing the expansion valve at *X* Its temperature is thus lowered and it absorbs heat from the water in the conditioning tank This heat, together with that produced in compressing the gas, is removed by a water-cooling system, such as a water jacket, represented by *C* The water running through this jacket may be controlled manually by the valve *D*, or automatically by the solenoid valve *E*

<sup>1</sup> The Laws of the Development of X-ray Films  
RADIOLOGY, September, 1925

<sup>2</sup> Recent experience indicates that 100 feet of  $\frac{3}{4}$  inch inside diameter copper tubing would be better

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cession due to small unavoidable fluctuations in temperature, a double throw switch, *H*, is installed as shown. It is necessary to throw this switch at least twice a year, once to the heating side for

The heat exchanger consists of a large heat-insulated tank about 12 inches in diameter and 5 feet high in which is placed a coiled copper tube (150 feet of  $\frac{5}{8}$  inch tubing), as indicated in Figure 1. Water

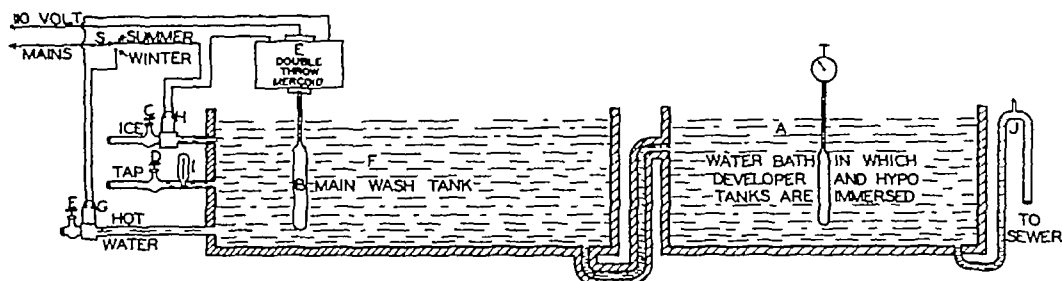


Fig. 2 Method for use where ice water, tap water, and hot water are available

winter operation, when the temperature of the incoming water is below  $65^{\circ}\text{F}$ , and again in the summer to the cooling side when this temperature rises above  $65^{\circ}$ . By means of another Mercoid switch with its bulb in the cold water main, this change-over could be made automatic, but this is an additional expense and is not desirable because the compressor requires attention after shutting down for the winter and before starting up for the summer. The water from the conditioning tank enters the dark room and flows past an immersion bulb dial thermometer, *T* in Figure 1, which indicates to the dark room technician the temperature at all times. The water flows into a large tank in which the developer and hypo containers are immersed. The films may be rinsed in this tank between the developer and hypo immersions. Water from the conditioning tank also flows into the main wash tank where the final washing is done. The outflow goes from here into a cascade wash tank where films from the hypo bath are given a preliminary washing before being placed in the main wash tank. The outflow from this cascade wash tank, together with that from the water bath in which the developer and hypo tanks are immersed, is conveyed in a heat-insulated pipe to the heat exchanger and from there to the sewer.

from the cold water main enters the upper end of this coil and goes out through the lower end to the conditioning tank. In its passage through the heat exchanger the incoming water in the coil is brought to nearly the desired temperature of  $65^{\circ}\text{F}$  by the waste water from the dark room. This, of course, economizes on the work done by the conditioning tank. It is obvious that in order to obtain the maximum possible help from the heat exchanger, it is necessary that the waste water from all tanks be conducted to the exchanger through heat-insulated pipes (compare Fig. 1). Under these circumstances, the volume flow of waste water is equal to that of the incoming tap water.

Thermometers may be put at such critical points as *J*, *K*, *L*, and *M* to check the functioning of the system but these are not necessary. The system is entirely automatic except for the summer-to-winter change-over. The best location for the equipment is in the basement below the dark room, the space required being about  $4 \times 8$  feet floor space by  $7\frac{1}{2}$  feet height.

*Method II*—Where ice water, as well as tap water and hot water, is available (Fig. 2)

In this installation the incoming tap water is mixed with hot water or with ice water, depending upon whether or not its temperature (as indicated by *I*) is below



The other coil, *B*, is connected to a hot water line and functions when the temperature of the incoming water, as indicated by *J*, is below 65° F. The water from the conditioning tank is conveyed to the dark

electrodes sealed in the glass. This actuates the motor relay which starts the motor *O* and compressor *R*. The compressed gas expanding in coil *A* cools the water in the conditioning tank. When the tem-

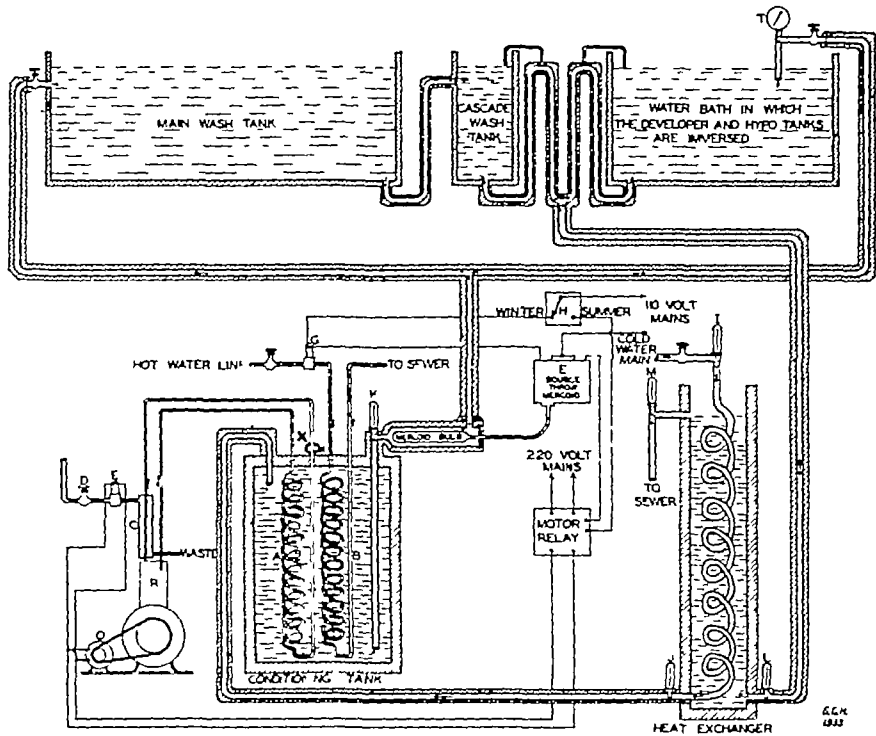


Fig 1 System employing compressor with cooling coils, hot water coils, solenoid valves, and a double throw Mercoid switch

room through heat-insulated pipes. By regulating the action of the refrigeration coil, or the hot water coil, the temperature of the water leaving the conditioning tank is brought to the proper point. This is accomplished by the use of a double throw Mercoid switch. The Mercoid switch consists of a metal bulb (the type known as "extra long bulb" should be used) connected through a small tube to a pressure drum arrangement. The bulb contains a fluid which volatilizes. When the temperature of the water in which this bulb is immersed, rises to a certain height, the pressure increases in the bulb. This tilts a glass tube partially filled with mercury. The mercury, falling to the lower end of the tube, closes the circuit between two

peratures of the water in the conditioning tank falls below a predetermined value, the pressure in the Mercoid bulb decreases. This tilts the mercury tube in the opposite direction, breaking the electrical contact between the electrodes sealed in the glass, thus stopping the motor and compressor. A second mercury tube, similar to the one described, but with contacts in the opposite end, is fastened alongside of the first one so that the two tilt together. In this way, one opens its contacts when the other closes them. The latter actuates the solenoid valve *G*, allowing hot water to circulate through the coil *B* and heat the water in the conditioning tank.

In order to prevent the heating and cooling coils from operating in rapid suc-

siderable periods of time. In tank *D* are placed the developer and hypo containers. The film-washing may be done

tion unit operates intermittently "on" about two-thirds of the time. Naturally, when the temperature of the incoming tap

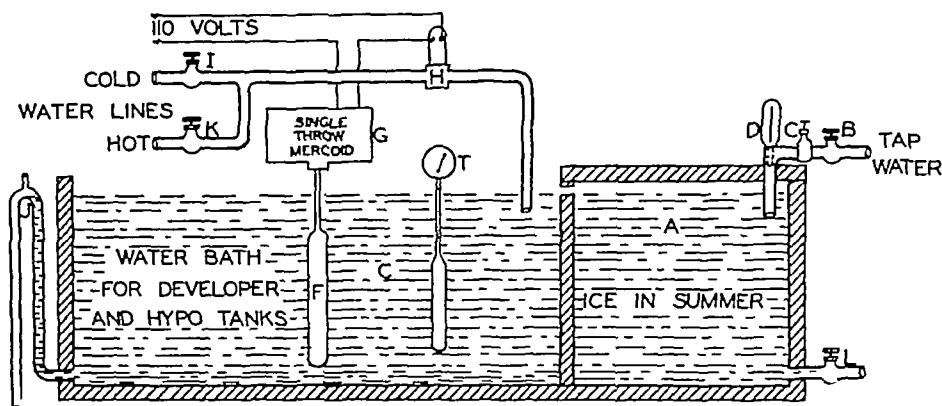


Fig 4 Method for use where ice is used for cooling and hot water for heating, with a single-throw Mercoid switch

here, but it is preferably done in a separate tank if a large volume of work is being handled. (If such a separate washing unit is installed, the arrangement of Figure 2 is followed, so that the fresher water is available for the final washing.) The bulb *E*, of a single throw Mercoid unit, operates the switch when the temperature of the water falls below  $65^{\circ}$ . This opens the solenoid valve *H* and allows water from the incoming tap water mains to flow into tank *D*. During the part of the year when the refrigeration equipment is in use, the temperature of the incoming tap water is above  $65^{\circ}$  F. Therefore, the valve *G* is closed and the valve *F* is opened. When the water in the tank *D* is warmed to about  $66^{\circ}$ , the Mercoid switch opens and the solenoid valve shuts off the tap water. In this way the temperature of the solutions is kept within narrow limits. In operation, it will be found that the needle valve *C* must be rather carefully adjusted. If opened too widely, especially during midsummer, the refrigeration unit will be overworked (will run constantly instead of intermittently), and the temperature of the tank system may rise above the desired level. In midsummer, this valve *C* is properly adjusted when the refrigera-

tion unit operates intermittently "on" about two-thirds of the time. Naturally, when the temperature of the incoming tap

water is less elevated, as in the spring and autumn, the refrigeration unit will be in operation for a smaller proportion of the time. As stated above, we have found it desirable to place the temperature control of the DRD-4 unit at the extreme warm end of its range (about  $45^{\circ}$  F).

*Method IV*—Ice is used for cooling and hot water for heating, with a single throw Mercoid switch (Fig 4)

With this method, in the summer, ice must be carried into the dark room and placed in the heat-insulated tank *A* (Fig 4). Water passing into this tank is manually regulated by the needle valve between *B* and *D* and after being cooled by the ice, flows over into the large tank *C*. This flow is constant and is maintained as small as possible consistent with keeping the temperature of the main tank down and allowing for sufficient washing of the films. The partition between tanks *A* and *C*

or above 65° F. The moving occurs in the large tank, *F*, in which the film washing is done. Since the films are first

*Method III*—For adapting a milk-cooling unit, "DRD-4," to the x-ray dark room

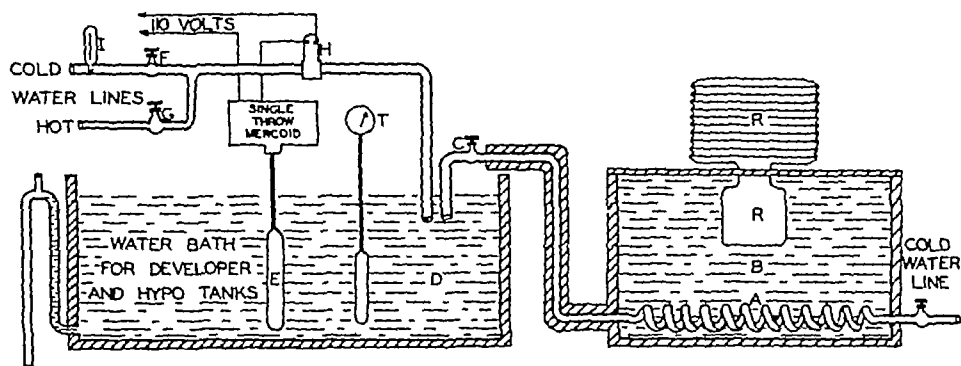


Fig 3 System employing a milk-cooling unit with cooling coil tap and hot water lines and single-throw Mercurid switch with solenoid valve

washed (between developer and hypo, and then after the hypo) in tank *A*, the pollution of the wash water is lessened by having the flow of water from tank *F* into tank *A*. The temperature of the water is regulated by means of the double throw Mercurid switch, *E*, similar to that described in Method I. An appropriate flow of tap water is admitted to the tank *F* by the manually controlled valve, *D*. For summer operation, the double throw mercurid switch is connected to solenoid valve *H* by switch *S*, as indicated. For winter operation, *S* is changed so as to connect solenoid valve *G*. When the water around the bulb drops below 65° F. the Mercurid switch actuates solenoid valve *G*, which allows hot water to flow. This brings the temperature in tank *F* to a little over 65° F, causing the Mercurid switch to open the electrical circuit and shut off the hot water. In the summer, when the temperature of the incoming tap water is above 65°, the valve *E* is closed, *C* is opened, and the switch *S* changed. The Mercurid switch then opens the solenoid valve *H*, allowing ice water to flow into tank *F*. When the temperature is a fraction of a degree below 65° the Mercurid switch closes valve *H*. A dial thermometer, *T*, is placed in the water to check the temperature at all times.

The above unit has many advantages from the standpoint of the roentgenologist, chief among which are cleanliness, silence, and the fact that all moving parts are hermetically sealed in the compressor compartment. The design is such that we were not successful in arranging the temperature control to turn the compressor on and off at the 65° to 68° temperature level, but this compressor is fitted with its own temperature (pressure) regulator which, when set at maximum temperature (warm end of range), will maintain a temperature of about 45° F. The motor of this unit is of only  $\frac{1}{2}$  H. P. and when the incoming tap water registers 80° to 85° F, as in Philadelphia during the months of July and August, one is limited to a maximum possible flow of about one-fourth gal per minute if 65° is to be maintained in the tank system.

Referring to Figure 3, water from the cold water main enters the copper coil *A* (50 feet of  $\frac{3}{4}$  inch tubing). This coil is immersed in a water-filled tank, *B*, into which is immersed the cooling coil *R* of the refrigeration unit. Water in the coil *A*, after being cooled, is manually regulated by the valve *C* so that a small stream enters the large tank *D*. Valve *C* should be a good needle valve and when once adjusted need not be touched for con-

siderable periods of time. In tank *D* are placed the developer and hypo containers. The film-washing may be done

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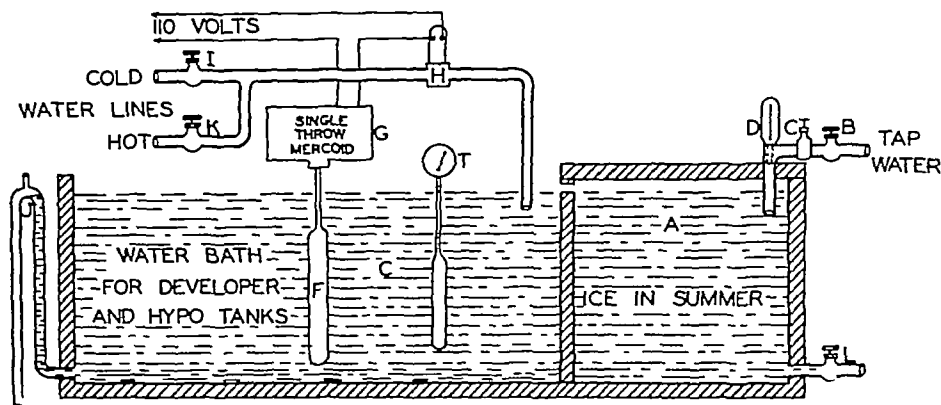


Fig 4 Method for use where ice is used for cooling and hot water for heating, with a single-throw Mercoid switch

here, but it is preferably done in a separate tank if a large volume of work is being handled. (If such a separate washing unit is installed, the arrangement of Figure 2 is followed, so that the fresher water is available for the final washing.) The bulb *E*, of a single throw Mercoid unit, operates the switch when the temperature of the water falls below 65°. This opens the solenoid valve *H* and allows water from the incoming tap water mains to flow into tank *D*. During the part of the year when the refrigeration equipment is in use, the temperature of the incoming tap water is above 65° F. Therefore, the valve *G* is closed and the valve *F* is opened. When the water in the tank *D* is warmed to about 66°, the Mercoid switch opens and the solenoid valve shuts off the tap water. In this way the temperature of the solutions is kept within narrow limits. In operation, it will be found that the needle valve *C* must be rather carefully adjusted. If opened too widely, especially during midsummer, the refrigeration unit will be overworked (will run constantly instead of intermittently), and the temperature of the tank system may rise above the desired level. In midsummer, this valve *C* is properly adjusted when the refrigera-

tion unit operates intermittently "on" about two-thirds of the time. Naturally, when the temperature of the incoming tap

water is less elevated, as in the spring and autumn, the refrigeration unit will be in operation for a smaller proportion of the time. As stated above, we have found it desirable to place the temperature control of the DRD-4 unit at the extreme warm end of its range (about 45° F).

*Method IV*—Ice is used for cooling and hot water for heating, with a single throw Mercoid switch (Fig 4).

With this method, in the summer, ice must be carried into the dark room and placed in the heat-insulated tank *A* (Fig 4). Water passing into this tank is manually regulated by the needle valve between *B* and *D* and after being cooled by the ice, flows over into the large tank *C*. This flow is constant and is maintained as small as possible consistent with keeping the temperature of the main tank down and allowing for sufficient washing of the films. The partition between tanks *A* and *C*

should be made of a fairly good heat-insulating material. The developer and hypo tanks are placed in *C* and all of the film-washing is done here. Thus if only a very small amount of water from *A* is allowed to flow, the wash water may become too contaminated, whereas if too much water is allowed to flow, it uses up the ice too rapidly.

The constant flow of ice water from *A* is warmed to  $65^{\circ}$  by the tap water in the summer. In the winter when the incoming tap water, as indicated by *D*, is below  $65^{\circ}$ , no ice is used in *A*. In this case, valve *I* is closed and *K* opened, so that again cold water enters tank *C* from *A* and warm water from *H*. The temperature is regulated as described in the other methods, by the Mercoid switch *G* and the solenoid valve *H*. The tanks *A* and *C* are surrounded by heat-insulating material. Tank *A* may be partially emptied before being replenished with ice, by opening valve *L*. The water level in *C* is maintained by the inverted *U*-pipe, as indicated. Water is drawn off from the bottom of the tank so as to encourage better circulation and lessen contamination.

*Method V*—Where ice is used outside of the dark room and hot water is available.

In this installation the set-up is just the same as that shown in Figure 3, except that the cooling in tank *B* is accomplished by means of ice instead of the refrigerator unit *R*, and tank *B* is placed at some convenient point outside of, instead of in, the dark room.

If space is available outside of the dark room and on the same level as the water bath, then the arrangement in Figure 4 may be used. Tank *A* is placed outside and connected with tank *C* through a heat-insulated pipe. This saves the copper coil shown in Figure 3.

The reader may not be familiar with the "siphon-drain type" of waste pipe connection shown by our Figure 1 (incompletely diagrammed in Figures 2, 3, and 4), and it is not essential. The simple ordinary standpipe arrangement, or the placing

of the waste pipe outlet at the desired water level, would be applicable. The "siphon-drain" arrangement has the advantage of taking the waste water from the bottom of the tank (where impurities, especially heavy salts, tend to accumulate) instead of from the top. While not strictly included within the title of this paper, it is necessary to discuss certain difficulties which may be encountered in installations of the types indicated. For example, the drains in Figures 2, 3, and 4 will maintain proper levels and will avoid overflow, but will not remove floating particles or scum. To obviate this difficulty, one manufacturer has used the arrangement shown in Figure 1. With this arrangement, scum and other floating matter are removed, because surface water is removed by suction each time that the syphon operates and is broken at the water level. However, if a heat exchanger is installed, below the dark room, as shown in Figure 1, or if the waste runs into an unvented trap, air can accumulate in the pipe connecting the syphon to the heat exchanger or trap, resulting in a back-pressure which will prevent the syphon from functioning before the wash tank or water bath overflows on the floor. To prevent this, a small standpipe reaching above the tank-water levels may be inserted in the horizontal limb of the drain pipe under the dark room tanks, allowing accumulating air to escape.

#### PRINCIPLES INVOLVED IN THE APPLICATION OF REFRIGERATION ENGINEERING TO THE DARK ROOM

The reader may have no special interest in the vocabulary or formulæ of the refrigeration engineer. However, a few simple facts will enable the radiologist to examine critically the devices offered by the salesmen of refrigeration equipment and protect himself from an investment in inadequate or overpowered devices.

It may be stated at the outset that the horsepower required for the extraction of heat from water is much larger than is generally understood. To the uninitiated it may seem that a small "water-cooler,"

such as we sometimes place in our offices or corridors for the production of cool drinking water, might be adapted to the needs of the x-ray dark room. Such is not the case, for the simple reason that the

suitable arrangement of tanks ("cascade tank" of Figure 1, for example), the pollution of the main wash tank by hypo can be kept so low that a flow of one-half gallon per minute, or, at the most, 1 gallon

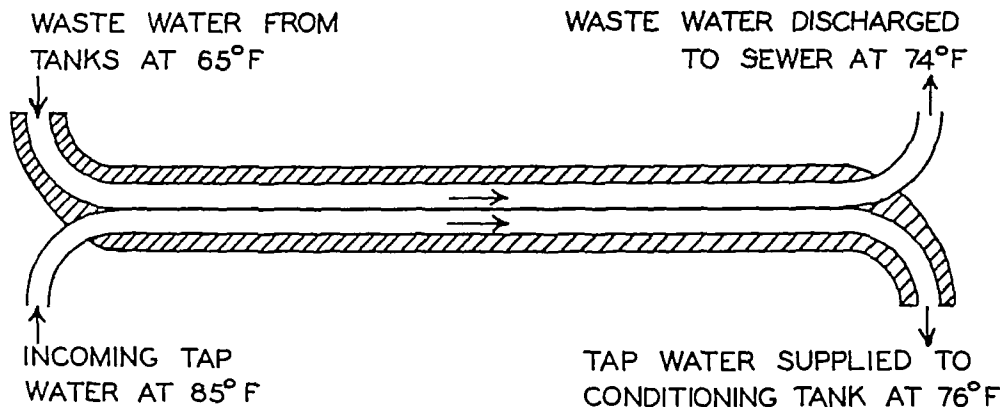


Fig 5 Principle of the "heat exchanger" in which the flow of the two streams of water is in the same direction. For illustration, we have assumed that exchange of heat occurs until the two compartments are within  $2^{\circ}$  of each other. In actual practice, the completeness of the interchange will depend upon volume flow (duration of "contact" between the two streams), rate of heat conduction through the walls of the tubing, and other factors. Volume flow of waste water and incoming tap water are assumed to be equal.

flow of water required for washing x-ray films is such that a low-powered drinking water-cooler would hardly produce a measurable change of temperature.

What are the actual power requirements? The refrigeration engineer knows that when used for cooling water, with a suitable refrigerant such as methyl chloride, ethyl chloride, sulphur dioxide, or ammonia, and with an efficient compressor, a 1 horsepower motor will extract 8,000 British thermal units of heat per hour. Since 1 gallon of water weighs approximately 8 pounds, and since a Btu is the amount of heat added or subtracted when the temperature of 1 pound of water is raised or lowered 1 degree Fahrenheit, it follows that the 1 H P motor and compressor will lower the temperature of 1,000 gallons 1 degree per hour. In other words, if the flow of water into our tanks amounted to 1,000 gallons per hour (16.7 gallons per minute), the 1 H P unit would lower the temperature only 1 degree F. Fortunately, such large flows are unnecessary. By a

per minute, is ample. Accepting the latter figure as desirable, and disregarding, for the moment, the aid that can be realized from a "heat exchanger," we must next examine the probable temperature drop which will be required during the hottest months of the year. In our own experience (Philadelphia), incoming tap water temperatures reach  $85^{\circ}$  F in July and August, which requires lowering the temperature 20 degrees, an extraction of 9,600 Btu per hour (power requirement, at least 1.2 horsepower).<sup>3</sup>

The actual requirements (flow of water) are slightly greater in the system advocated for the busy dark room (Fig 1), because approximately one-half gallon per

<sup>3</sup> One gallon per minute = 60 gallons per hour  
Sixty gallons weigh approximately 480 pounds  
Four hundred and eighty pounds lowered 20 degrees = 9,600 Btu  
Eight thousand Btu per hour require 1 H P (minimum)

Therefore 9,600 Btu will require  $\frac{9,600}{8,000} \times 1 \text{ H P} = 1.2 \text{ H P}$

minute is used for the flow into the water bath ("master tank") in which the developer and hypo inserts are placed. This is in addition to the one gallon per minute already appropriated for the wash tank,

debted to Robert R. Newell, M.D., Professor of Medicine (Radiology), Stanford Medical School, for calling our attention to this principle.)

It will be noted that the heat exchanger

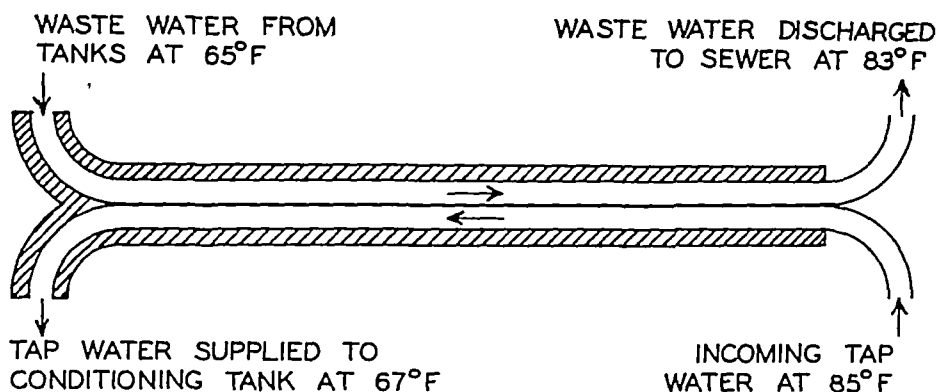


Fig. 6 Principle of the "heat exchanger" in which the flow of the two streams of water is in opposite directions (Compare Fig. 5)

requiring a total of one and one-half gallons per minute, or 1.8 horsepower. It is fortunately possible to design a fairly inexpensive "heat exchanger" which materially reduces this power requirement.

#### HEAT EXCHANGERS

It is obvious that admixture of a gallon of water at  $85^{\circ}$  and a gallon of water at  $65^{\circ}$  will produce two gallons of water at (approximately)  $75^{\circ}$ . At first glance it might appear from this that a heat exchanger operated by waste water at  $65^{\circ}$  is operating at 100 per cent efficiency if its discharge of waste water is at  $75^{\circ}$  and its tap water stream is cooled from  $85^{\circ}$  down to  $75^{\circ}$ . This would certainly be the case in an arrangement such as that of Figure 5. However, the exchange of heat between the waste water and tap water compartments will always be incomplete. In Figure 5 we have assumed that exchange ceases at about two degrees difference (between the compartments).

However, a simple rearrangement of the apparatus, as in Figure 6, produces the possibility of a surprising increase in the desired exchange of heat. (We are in-

shown in Figure 1, which we have used for several years, fulfills the requirements of Figure 6 as to direction of flow. The waste water enters the open tank (an old 20-gallon "hot water boiler" from which one end has been removed) at its bottom. In the summertime, when the action of the heat exchanger is most important, the waste water is progressively warmed as it moves upward in this tank. Convection currents are thus avoided. (If the relatively cool waste water from the tanks were brought in at the top of the open tank, convection currents would quickly destroy the desired temperature gradient.) The incoming tap water enters the copper coil at the top, and does not reach the cool end of the exchanger until it has been progressively cooled by passage through the entire length of the exchanger, thus fulfilling the requirements of Figure 6.

Unfortunately, the open tank type of heat exchanger is difficult to incorporate in the x-ray laboratory unless space is available on the floor below. Various makeshifts must be resorted to in cases in which this arrangement is impossible. For example, the waste water from the

tanks may be run into one end of an open tub on the same floor level as the dark room. From the other end of this tub, or tank, the water is discharged into the sewer. The incoming tap water from the dark room is run through a coil of copper tubing which is immersed in the tub. The direction of flow favorable for the most efficient exchange of heat is that indicated in Figure 6. The tub should be heat-insulated and long and narrow, to discourage convection currents from equalizing the temperature between the inflow and outflow ends.

In designing the heat exchanger it may be useful to know that the volume capacity of one-half inch inside diameter tubing is one gallon per 98 feet, and of five-eighths inch inside diameter tubing, one gallon per 63 feet. An adequate length of tubing should be incorporated so that the incoming tap water requires some minutes for its passage through the exchanger, otherwise sufficient time will not elapse for the desired change of temperature.

It is obvious that there are many possible

designs for a heat exchanger. For example, one could be built in substantially the form of our Figure 6. Co-axial tubes at once suggest themselves. Experience indicates that such theoretically desirable arrangements are impractical because of the rapid accumulation of clogging vegetable matter in the waste pipes from film-washing tanks. (This may be due to a combination of gelatin, bacteria, and algæ, at any rate, it is quite marked.) The same objection holds for any closed tank system, in which cleansing of the waste water compartment would be difficult or impossible.

#### SUMMARY

1 The desirability of automatic, year-round temperature regulation in the x-ray dark room tanks is discussed.

2 Various methods of accomplishing the desired result are described.

3 The essential formulæ of the refrigeration engineer are reviewed, together with fundamental principles for the design of "heat exchangers."

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# THE CLINICAL AND ROENTGENOGRAPHIC INTERPRETATION OF LUMBOSACRAL ANOMALIES<sup>1</sup>

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THE significance of lumbosacral anomalies is closely related to certain clinical concepts which, in turn, have distinct bearing on the treatment. For this reason, these clinical concepts and treatment will be discussed before the various common anomalies are described.

Lumbosacral anomalies produce symptoms only through faulty mechanics. Faulty support or faulty relationship produces abnormal stresses or pressures. Whether an anomaly is of faulty support or of faulty relationship, its mechanical weakness can be compensated by muscles and ligaments. As long as these soft tissues are of sufficient strength and tone to meet the conditions without fatigue, there are no symptoms—the patient is compensated.

Muscles and ligaments that are thus occupied in supporting or protecting the lumbosacral area have less than normal capacity for meeting extraneous loads or stresses, as a certain portion of their total capacity is already in use. Hence these tissues are more liable to strain than the normal, that is, their capacity to meet stresses is more liable to be exceeded, in which event the patient is decompensated and must be relieved by rest in order that these injured tissues may recover and regain a state of compensation.

*Decompensation* occurs in several ways.

(1) There may be an excessive extraneous load or stress directly producing a strain.

(2) As one grows older, muscles lose tone and power, so that the person who is well compensated at 20 may, at 40, have his muscle power exceeded by stresses which were easily met at 20. Accordingly, decompensation is more frequent later in life.

(3) One's routine may change from a physically active to a sedentary life. The muscles which were of good power and tone rapidly become weaker and poorer in tone so that muscles which, in the period of activity, could meet severe stresses, in the sedentary period are not equal to meeting even moderate stresses, and decompensation occurs on some slight injury. Women lead a fairly active life up to the time of marriage but on the average are much more sedentary thereafter. This, I believe, is the reason that backache of lumbosacral origin is so common among women, while many laborers who do heavy work, with muscles of good tone and power, escape it.

(4) Muscles able to meet considerable stress when prepared for it may offer little resistance if caught unprepared. The person with a lumbosacral anomaly may do heavy work with no difficulty and yet develop an acute strain with some sudden twist or turn for which the protective muscles are not prepared.

(5) Muscles that are being used constantly for protection while the patient is erect may become fatigued. Fatigued muscles may ache. This is a minor form of decompensation without acute strain but with definite low-back fatigue. Some patients, not having known any other condition, may not realize that they are fatigued. Such persons are apt to lead a sedentary life merely because they do not feel equal to anything else. Often the adolescent child who is lazy, sedentary, or a book-worm has adopted that habit because of a lumbosacral anomaly which produces chronic fatigue.

Some patients present obvious examples of these mechanisms of decompensation. A man 36 years of age worked steadily as a laborer until he was laid off for three weeks. On returning to his usual work he

<sup>1</sup> Read before the Lake Keuka Medical Association, Lake Keuka, N. Y., July 14, 1933.

immediately suffered a lumbosacral strain. During his lay-off period, the muscles had lost tone and power so that they were no longer able to meet stresses with the same ease as previously. If he had not been laid off, or if he had resumed work gradually, he probably would not have become decompensated. Case histories of this character are frequent in these days of interrupted or part-time labor, and can probably be prevented only by examining those destined for heavy but interrupted labor and excluding from such a régime those having lumbosacral anomalies.

An All-American football player had extensive spondylolisthesis. During his athletic days his muscles and ligaments were of such power and tone that he had no trouble with his back—he was fully compensated even for the stresses of playing football. Later, he became a bond salesman. He then led a sedentary life and, of course, his muscles gradually lost power and tone. Finally a slight jolt in a taxicab produced an acute strain.

Another football player, a young man, could easily carry a hundred-pound pack all day on a hunting trip with no difficulty, but he experienced frequent lumbosacral strains if he did not avoid sudden turns and quick twists. These were apt to catch his protective muscles unprepared and so produce a strain.

*Prophylaxis*—The conception of compensation and decompensation which has been stated points the way for the treatment or prophylaxis of these conditions. For mild cases it is essential to build up muscle tone and power sufficiently to meet the stresses, that is, to keep the patient compensated. This is a matter of widespread application. A majority of women and many men have backache of lumbosacral origin by the time they are 40. That the bony mechanism should be inadequate to meet the stresses of the erect posture in a majority of persons is not surprising, as our spines were unquestionably developed for the horizontal posture and have not yet become well adapted to the vertical

The means of building up muscle tone and power are simple but the patient is not apt to expend the effort to accomplish them and will rarely acquire a clear conception of what is necessary. The patient does not always distinguish properly between work and exercise. In the use of a muscle, decomposition products accumulate, circulation removes these products. The repeated use of a muscle through a limited range of motion accumulates these products without, at the same time, aiding the circulation. This is work, and fatigue results—a condition which is to be avoided. The contraction of a muscle through its full range accumulates decomposition products, but at the same time exerts a forceful stimulus on the circulation, the complete contraction squeezing out interstitial fluid like water out of a sponge, and leaves the tissues more free of decomposition products after the contraction than before. This is exercise and, by improving the circulation, it improves the muscle tone. The circulation may be further improved by massage, steaming, and by contrast baths. Power may be improved by making the movements through the full range of motion against resistance, to be gradually increased from day to day.

Although much can be accomplished for relief or prevention of lumbosacral decompensations when all this is understood and applied by the patient, actually few will or can apply it beneficially. Usually, therefore, the patient drifts along and has a certain number of decompensations unless resort is had to surgery.

*The fusion operation*, to eliminate motion and provide stability, is indicated when the attacks become so frequent and so severe that it becomes worth while for the patient to give up the time necessary for the operation in order to put an end to the attacks. The stage at which this shall be done is largely a matter for the patient to decide. If it is worth while for him to give up from three to six months for hospitalization and convalescence rather than endure the attacks, he is a proper case for operation. The

younger patient with frequent attacks, rather than the older patient, should be urged to have surgical treatment, while he is in better condition for operation than he will be later on when surgery may become unavoidable

Many of these individuals have chronic arthritis in the spine as well as a lumbosacral anomaly. Such cases are not favorable for surgery, as complete relief cannot be expected, due to the arthritis in areas which are not to be fused. The orthopedist must thoughtfully judge what portion of the symptoms is due to the anomaly, and whether elimination of that portion by surgery will be worth while for the patient

*Belts and Braces*—The patients who are not affected sufficiently to justify surgery may be treated by other means. The use of support by means of a belt, corset, brace, or plaster may be necessary to relieve an attack but must not be continued indefinitely. Disuse of the muscles causes them to become weaker so that there is more and more need for the support and finally the patient is as little able to avoid strains with the support as he was formerly without it. The acute attack is better treated, when the patient will consent to it, by rest in a bed that does not sag, that is, a bed with a board between the mattress and the springs. Such treatment eliminates the necessity for support. Manipulation sometimes relieves an acute attack

*The symptoms and signs* associated with lumbosacral anomalies may be divided into two classes. (1) The general features which may be associated with any anomaly, (2) The special features associated with a particular anomaly

The important general features are as follows. The patient has a weak back and there is a tendency to tire easily, the fatigue being felt particularly in the lower part of the back which may lead to an aching pain in the same area. Again, there may be acute pain, in intermittent attacks, usually increasing in frequency and in duration of the individual attacks

There is a history of injury associated with the onset of the attacks of pain in somewhat more than half of the cases, although the injury may be trivial. The pain, which is affected by motion, exertion, or position, is relievable by rest. It may be associated with a particular motion, may be local in the lumbosacral area, or may radiate to the buttocks, hips, thighs, calves, sciatic nerve, or coccyx. Lumbosacral anomalies are probably the commonest cause of sciatica and coccygodynia, and a common cause of hip pain

There may be paresthesias such as numbness, tingling, or sensation of heat or cold in the areas of radiation. These sensations may be present with or without acute pain. The radiations may be bilateral or unilateral to either side, regardless of the type of lesion or side on which the anomaly is located

There may be spasm in the lumbosacral area, the spine being held stiff, with motion limited. Tenderness may be present in the lumbosacral or sacro-iliac areas. Often there is pain on passive motion on rotation, flexion, extension, or side bending of the lumbar spine, or flexion of the hip with the knee extended

Other symptoms or signs associated with particular anomalies will be mentioned with them

*Diagnosis* rests upon

(1) The roentgenologic demonstration of an anomaly capable of causing the symptoms present

(2) Pain or fatigue aggravated by exertion, especially some particular motion, and relieved by prolonged rest

(3) Absence of demonstrable cause of symptoms other than the lumbosacral anomaly. That is, gynecologic, intestinal, genito-urinary, or skeletal disease which might cause the symptoms must be carefully ruled out

There is no positive differentiation, by physical examination, between lumbosacral anomalies and so-called sacro-iliac strain. The results of surgical treatment indicate that when there is no definite sacro-iliac abnormality visible in the roent-



Fig 1 On the right, the lumbosacral arch articulation is internal-external, the joint space is seen clearly between the facets. On the left, the arch articulation is anteroposterior, the joint space is not visible, and the two facets almost completely overlap each other. This is severe asymmetry of the arch articulations.



Fig 2 The laminae of the first sacral vertebra are not united to each other. The ossification center for the spine of this vertebra has not united to the laminae, but is united by fibrous tissue to the spine of the fifth lumbar vertebra. This has the effect of prolonging the fifth lumbar spine downward between the sacral laminae. This is a 45° view, that is, an oblique inferior-superior anteroposterior view. It is used to show the sacro-iliac joints, the wings of the sacrum, the laminae of the fifth lumbar vertebra, and the relation of the sacral wings to the lumbar transverse processes.

genogram, the lumbosacral area rather than the sacro-iliac joints must be suspected as the source of symptoms.

The demonstration of the presence of the lumbosacral anomaly is a roentgenographic problem requiring, in some instances, rather extensive examination. The methods of examination will be mentioned in connection with the more frequent types of anomaly.

*The Normal*—To describe the normal lumbosacral area is a task I shall not attempt. It is usually accepted as being the average of a number of individuals, and the average lumbosacral area is abnormal. Our spines were developed for the four-footed position and are not yet adapted to the erect, so mechanical weakness at the lumbosacral area is usual rather than exceptional. We must con-

sider the lumbosacral area not as normal or abnormal but as mechanically sound or mechanically unsound.

*The Articular Facets*—Stability, or sound mechanics, at the lumbosacral area depends in a great degree on the lumbosacral arch articulations. The most stable condition is present when the facets are of the internal-external type, that is, when the joint is in the sagittal plane (Fig 1). In the roentgenogram, such a joint shows clearly, as the plane of the joint corresponds with the plane of the anteroposterior view. There may be variations from this type in many ways: the facets may incline laterally, they may be rudimentary, irregular, defective, or in various planes from the sagittal to the trans-

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verse. The latter type (Fig 1) are called anteroposterior facets and are unstable in that they allow an undue amount of motion at the lumbosacral joint. Such motion may cause trouble in various ways, as we shall see later.

Probably the worst type of facets, considered mechanically, are those which are asymmetrical. There is severe asymmetry when one facet is internal-external and the other anteroposterior (Fig 1). With such a mechanism, every motion must put undue strain on one or the other of these facets as they do not operate in the same plane. Practically every person with a severe degree of asymmetry of these facets has symptoms referable to the lower part of the back. Such facets are particularly liable to acute strains on twisting movements and the condition is especially difficult to combat by other than surgical measures because of the difficulty of avoiding or preventing rotatory movements.

Other anomalies may be present when the facets are mechanically inferior, and in the presence of such other anomalies, the character of the facets is an important factor in determining the presence and degree of symptoms. When any anomaly is present the facets should be examined if they are found to be poor; the hope of maintaining compensation is much less than it would be if they were mechanically stable.

*Posterior Defect*—The laminae of the fifth lumbar or first sacral vertebra may not be united to each other. When the defect is broad with protrusion of a sac from the spinal canal, the condition is a spina bifida. With the defect narrow and with no protruding sac, it is often referred to as spina bifida occulta, on which many ills have been unjustly blamed. Such a defect we refer to simply as a posterior defect, and we do not consider it of any importance except that it contributes a little additional weakness when other defects are present. There are, however, some variations of this defect which do achieve significance. The ossification cen-

ter for the spine of the first sacral vertebra may be present as a free piece in the arch between the laminae. This free piece may be united to the spine of the fifth lumbar by fibrous tissue (Fig 2) or there may be bony continuity of these parts. This has the effect of prolonging the fifth lumbar spine downward between the sacral laminae, an anomaly which may be painful if any motion of the fifth lumbar vertebra puts pressure or pull on the laminae of the first sacral. A symptom peculiar to this condition is a sensation of pressure in the lumbar spinal column on extension or on pressure upon the fifth lumbar spine. The condition may be relieved by removing the long spine, or, if other anomalies which necessitate it are present, by fusing the fifth lumbar vertebra to the sacrum.

*Transitional Vertebra*—One of the common anomalies is a transitional vertebra (Fig 3). The transitional formation may be present on one or both sides and in any degree, from slight enlargement of the transverse process to pseudo-arthritis or even complete fusion to the sacral wing. It is called "transitional" because it is not truly lumbar or truly sacral in type. It may be the fifth lumbar or the first sacral. To prevent decompensation, anomalies of this type require sufficient bony union or sufficient muscular fixation to prevent motion. At the false joint between the wings there are periosteum and fibrous tissue, pressure upon which is painful. Motion produces such pressure, and if the motion is sufficiently sudden there is a contusion, with effusion or hemorrhage attempting to occupy the negligible space between the bony processes. There is then constant pressure till the swelling subsides. In this stage, any motion is a further irritant and hence a chronic painful condition may result.

Radiation of pain in this anomaly may be bilateral or unilateral and may be to either the right or left side, regardless of which side exhibits the anomaly. This lack of relation between the laterality of the anomaly and of radiated pain may be due in many cases to variations in the



Fig 3



Fig 4



Fig 5



Fig 6

Fig 3 A transitional vertebra. On the right, the transverse process of the fifth lumbar vertebra is of the sacral type and forms a pseudo arthrosis with the sacral wing. The arch articulations are poorly developed and are oblique. This is a 45° view.

Fig 4 Spondylolisthesis. The body of the fifth lumbar vertebra is displaced forward one-quarter of an inch on the first sacral. Failure of union of the laminae to the pedicles of the fifth lumbar vertebra (indicated by arrows) which allows the displacement.

Fig 5 The defect which allows spondylolistheses to occur may be seen in the arch of the fourth lumbar vertebra. Where the laminae approach the pedicles there is an irregular line where there is no bone—a complete defect across the laminae (indicated by arrows).

Fig 6 The same case as shown in Figure 5. The defect is also shown in this view (indicated by arrows). There is no displacement of the fourth on the fifth lumbar vertebra. This is prespondylolisthesis.

articular facets. In the presence of a transitional vertebra such as this there may be no symptoms if the arch articulations are well formed, but if they are poorly formed, symptoms are apt to be present and the side on which pain is felt is more constantly related to the type of the arch articulations than to the structure of the wings.

There may be union of the wing of the transitional vertebra to the sacral wing on one or both sides. Union on one side only cannot be relied on to prevent motion. We have a specimen exhibiting union on one side which does not prevent a definite amount of motion.

*Close Spines*—The spinous processes may be in abnormally close relation, this being much more common at the fourth and fifth lumbar than at the lumbosacral joint. Such close relation may allow painful pressure or contusion, and when pain develops it is apt to be persistent. A common cause of such pain is a contusion resulting from hyperextension while diving. After such an accident pain may be present for many months, especially on hyperextension. Local tenderness at the

spines involved is an important feature in this anomaly, while pain and tenderness are occasionally so chronic that one of the spines, or a part of one, has to be removed to eliminate the possibility of contact.

*Spondylolisthesis*—The fifth lumbar vertebra may be displaced anteriorly on the sacrum. The amount of displacement is shown in the true lateral view of the lumbo-sacral joint (Fig 4). The laminae of the fifth lumbar vertebra are not united to the pedicles, and when the body is displaced forward the spine and laminae are left behind. For this reason the spine of the fifth lumbar is prominent posteriorly. A depression may be felt and sometimes seen above it—a characteristic sign of spondylolisthesis. The arch of the fifth lumbar vertebra is often rudimentary. The transverse processes may completely overlap the sacral wings in the anteroposterior view, due to the anterior displacement.

How and when the displacement occurs has not been definitely determined. Of course, trauma may produce the displacement, and also there may be gradual slipping without trauma, although I have



not observed this in any case. The displacement does not have much, if any, tendency to increase spontaneously. I have not seen any increase in cases observed over a period of several years. Yet these cases have had several decompensations while under observation, which fact demonstrates that this condition is subject to the same conception of compensation and decompensation as other anomalies. Although attacks of severe pain may be due to increase of displacement, most of them are due to strains which occur because of the mechanical weakness, that is, they are due to decompensation. I will not be surprised if we eventually find that the displacement occurs in fetal life.

*Routine Examination*—The basic routine examination of the lumbosacral area should consist of a true anteroposterior and true lateral view, and an anteroposterior view oblique from below upward, commonly called the  $45^\circ$  view (Figs 2 and 3). Each of these films should be made in the true plane, with the patient lying in the normal relaxed posture. The hips should not be flexed nor the lumbar spine flattened, as such a position does not allow the normal mechanics of the region to be visualized. Other views which may be necessary in certain cases will be mentioned later.

The  $45^\circ$  view is of great value in the study of the sacro-iliac joints, the sacrum, the state of fusion of the sacral wings, the transverse processes of the fifth lumbar vertebra with their relation to the sacrum, and the condition of the arch of the fifth lumbar vertebra.

*Prespondylolisthesis*—The defect which allows spondylolisthesis to occur is usually visible in the lateral view, may be seen in the anteroposterior view, but is best demonstrated in the  $45^\circ$  view. The defect is in the lamina just before it joins the pedicles (Fig 5), and it may be present on one or both sides with or without displacement. When there is no displacement the condition is prespondylolisthesis (Fig 6). Acuteness of the lumbosacral

angle has nothing whatever to do with the question of whether or not prespondylolisthesis is present. The case shown exhibits no displacement of the fourth lumbar but has failure of union of the lamina to the pedicle on each side.

Whether or not there is displacement, the defect in the lamina may become united with advancing years, and many other congenital divisions show the same tendency. I have twice seen this defect unite while under observation, but do not consider this as evidence that fracture was present. Union of the defect does not prevent further attacks of decompensation. As symptoms are not present in some cases with displacement but may be present without displacement or with displacement and united defect, it is evident that symptoms are related to lack of stability rather than to the occurrence of displacement.

*Errors*—Spondylolisthesis is not a particularly uncommon condition, I have several times seen three cases in a single day. It is, however, often unrecognized because of failure properly to examine the lumbosacral area roentgenographically. In fact, the errors arising from failure to make true anteroposterior, lateral, and  $45^\circ$  views for the routine examination of this area are many, such as failure to detect anterior or posterior displacement or an unstable lumbosacral angle or to diagnose sacro-iliac strain because of failure to demonstrate lumbosacral anomaly. A recent article claims a relation between the occurrence of lumbosacral pain and thinness of the lumbosacral disc—there is no such relation. The disc which appears thin posteriorly (Figs 7, 9, 10, and 12) will almost always appear normal if the patient is examined in flexion (Fig 13), the condition is not a rupture of the disc but a phase of normal motion. The lumbosacral disc may be thin because of sacral type of development or lack of motion. (Motion during the growing period causes the disc to grow larger, while absence of motion prevents growth.) Only rarely is the disc significantly abnormal and then only in a few of the cases.

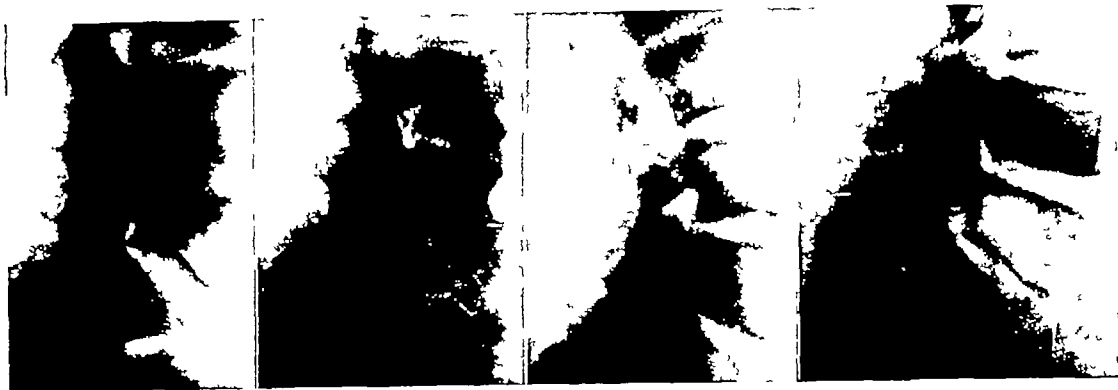


Fig 7

Fig 8

Fig 9

Fig 10

Fig 7 Posterior displacement of the fifth lumbar on the first sacral vertebra. The fifth lumbar vertebra is also tilted posteriorly, a fact which indicates that abnormal mobility may be present, and hence the displacement may not be constant. The lumbar spine has less lordosis than usual, this being common in posterior displacement. The lumbosacral angle is acute ( $52^\circ$ ).

Fig 8 Lumbosacral angle slightly acute, patient in a horizontal position.

Fig 9 Same case as shown in Figure 8, patient in an upright position. Compared with the horizontal position, the pelvis has tilted forward, lordosis is increased, and the lumbosacral angle is slightly more acute—there is "sag" at the lumbosacral joint. This is a normal reaction of symptomless spines when standing.

Fig 10 An acute lumbosacral angle ( $59^\circ$ ), patient in the horizontal position.

that have had severe injury or marked arthritis. Thin discs are as frequent in cases without symptoms as in those with symptoms. The cases in which the disc is thin posteriorly usually have excessive mobility, and lack of muscular control of this instability is the cause of decompensation, as in other conditions.

**Posterior Displacement**—While it is true several authorities have stated that posterior displacement of the fifth lumbar vertebra does not occur, the proper interpretation of such statements is that the authorities did not obtain true lateral views of the lumbosacral joint in their routine examinations. As a matter of fact, posterior displacement of the fifth lumbar vertebra is one of the commonest of the significant lumbosacral anomalies and one very commonly associated with symptoms.

Figure 7 shows the fifth lumbar vertebra displaced posteriorly about one-quarter of an inch. These displacements are often variable, varying with the position of the patient or they may be present at one time but not at another. The reason for this is that they occur when there is an abnormal amount of mobility of the fifth lumbar on the first sacral vertebra. In posterior

displacements the arch articulations are usually of anteroposterior type, as this is the type which allows most motion at the lumbosacral joint. This displacement may occur, however, with internal-external arch articulations and there is often slight or a questionable degree of displacement with asymmetrical arch articulations. There is usually decrease of the lumbar lordosis and sciatica is frequent.

Acuteness of the lumbosacral angle is no bar to posterior displacement (Fig 7), as the mechanism of the displacement is as follows. On hyperextension, the lumbosacral joint being hyper-mobile, the fifth lumbar glides backward on the first sacral vertebra—an exaggeration of the normal motion. Then on flexion, instead of gliding forward, the fifth lumbar tilts forward, being caught in the position of posterior displacement. The displacement may often be reduced by reversing this process, extending the spine, and then gently flexing it with traction on the pelvis. Reducing the displacement does not cure the condition, however, as the fundamental difficulty, which is still present, is the abnormal mobility which allowed the displacement in the first place.

*Unstable Lumbosacral Angle*—The lumbosacral angle may be mechanically unsound in one or both of two ways

that the edges of the film register the vertical and horizontal positions, the angle of the sacral surface to the horizontal edge



Fig 11

Fig 12

Fig 13

Fig 11 Same case as shown in Figure 10, patient in the upright position. The lumbosacral angle is now  $48^{\circ}$ . The pelvis has been tilted posteriorly, reducing the lumbosacral angle and bringing the surface of the first sacral vertebra more directly under the line of weight thrust. This is a "protective reaction."

Fig 12 Spine extended. The fifth lumbar vertebra is tilted posteriorly and slightly displaced in the same direction. The lumbosacral disc is thin posteriorly.

Fig 13 Same case as shown in Figure 12, spine flexed. There has been  $15^{\circ}$  motion of the fifth lumbar on the first sacral vertebra. The spines of these vertebrae have separated five-eighths of an inch. The disc is no longer thin posteriorly or elsewhere.

(1) The center of gravity of the trunk, as represented by a vertical line through the center of the third lumbar body, may pass anterior to the sacrum, sometimes as much as two inches. Insofar as this line is anterior to the sacrum, a certain portion of the weight is not sustained by bone, but by muscles and ligaments, which are, therefore, liable to strain.

(2) If the plane of the articular surface of the first sacral vertebra is too far from the horizontal, sheering stresses are set up which again make the muscles and ligaments liable to strain. When this surface is  $42^{\circ}$  from the horizontal axis of the patient these stresses are of some moment, when the angle is  $47^{\circ}$  they are a menace, when the angle is  $52^{\circ}$  or more the stresses are severe.

A method of measuring this angle is as follows. In the roentgen examination, the film is placed parallel to the patient so

being readily determined in the true lateral view.

An acute lumbosacral angle is shown in Figure 7 and in Figure 10. It is obvious that the sacrum does not offer proper support to the weight thrust, and abnormal stresses on the muscles and ligaments may be present. An unstable lumbosacral angle may, of course, be present with other anomalies and add to their effect.

*Protective Reaction*—The lumbosacral angle should be determined with the patient in a horizontal position, the reason being demonstrated in Figures 8 and 9. With a lumbosacral structure which is mechanically sound, the lumbosacral angle is more acute when standing than when lying, due to slight sagging forward of the pelvis on standing. If, however, there is a mechanical weakness which is producing the symptoms, the patient, on standing,

tilts the pelvis backward so as to reduce the lumbosacral angle and bring the sacrum more under the line of the weight thrust—a protective reaction as shown in Figures 10 and 11. For this reason the lumbosacral angle, with the patient standing, may appear worse in a normal subject than in one who has lumbosacral weakness. Accordingly, the angle must be measured with the patient lying in a relaxed posture. You may also deduce from this that the determination of the presence of a protective reaction, on comparing the results of an examination with the patient first in a horizontal position and then in a vertical one, serves to determine, in a questionable case, that symptoms are arising from the lumbosacral area, while absence of the protective reaction indicates that no symptoms are originating in this area at the time of the examination. In questionable cases we must, therefore, add to the routine examination a lateral view with the patient standing.

If the lying and standing views are to be compared, it is necessary that each be made in the habitual relaxed posture of the patient. The hips must not be flexed when the examination is made and each view must be a true lateral one.

**Abnormal Mobility**—When the examinations already mentioned have not revealed a definite anomaly and yet the symptoms seem to be of lumbosacral origin, a more extensive examination is indicated. The anteroposterior mobility of the fifth lumbar vertebra should be determined for the reason that abnormal mobility at this joint is just as much a mechanical weakness as is a bony anomaly. The amount of mobility is determined by making true lateral views in flexion and in extension (Figs 12 and 13). Fifteen or more degrees of anteroposterior motion, or a movement of the spines of the fifth lumbar and first sacral vertebrae, more than one-half inch relative to each other, constitutes sufficient mobility to be a cause of symptoms. Increased mobility may be sustained if the lumbosacral angle is near the horizontal, less if it is near the vertical. When



Fig 14 The posture in a case of 'slipping' fifth lumbar vertebra. The spine deviates to the left, displacing the trunk to that side. In this case pain was on the right at the lumbosacral junction.

symptoms are severe spasm may limit mobility, but such cases are not apt to be diagnostic problems because of protective reaction on standing being marked, and the clinical picture quite characteristic.

**"Slipping" Spines**—One of the possible results of abnormal mobility is a clinically characteristic condition which we call a "slipping fifth lumbar vertebra." The patient has a sudden attack of acute pain which as suddenly ceases, its onset or cessation being accompanied by a sensation of something slipping in the lumbosacral area, sometimes with an audible snap. During such an attack, the patient has a characteristic posture (Fig 14)

The fifth lumbar vertebra is tilted away from the painful side, the spine deviates in the direction of the tilt, the trunk being offset to that side, and the opposite hip is prominent. The peculiar posture is often more marked when the patient is standing than when he is recumbent. These patients may have no anomaly other than abnormal mobility. The condition may occur in patients with posterior displacement of the fifth lumbar but often there is no displacement. For these reasons the explanation of just what occurs is doubtful. It may be that there is a hernia of soft tissues into the space bounded by the sacrum, ilium, ilio-lumbar ligament, transverse process, and body of the fifth lumbar, and that the peculiar posture is an attempt to lift the transverse

process away from the tissues upon which it is pressing.

The chief varieties of lumbosacral anomalies have been exhibited, and, in conclusion, may we emphasize that which must be evident, namely, that the most important factor in determining the condition and clinical significance of the lumbosacral area is thorough examination. The routine roentgenographic examination should certainly include true anteroposterior, lateral, and 45° views. If these do not make the situation clear, they should be supplemented by lateral views in flexion, extension, and standing, anteroposterior view, standing, and, sometimes, oblique views to determine the relation of the fifth lumbar to the ilium or the plane of its articular facets.

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# DEPTH DOSES OF ROENTGEN RADIATION, STRIKING AT ANGLES OTHER THAN 90 DEGREES, MEASURED IN A WATER PHANTOM<sup>1</sup>

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## INTRODUCTION

THE distribution of the intensity of roentgen rays in a water phantom has been investigated by many authors, among whom are Dessauer, Glocker, Duane, Holfelder, Glasser, and Weatherwax. Together with variations in voltage, distance, filter, size of field, and posi-

of an even density. In other words, the investigations have been made under truly ideal conditions. The only authors to have varied the fourth condition have been Wintz and Rump, Weatherwax and Robb, Leddy and Witting, Glasser, and the writer.

It appears evident that the isodose curves of a given radiation will adopt dif-

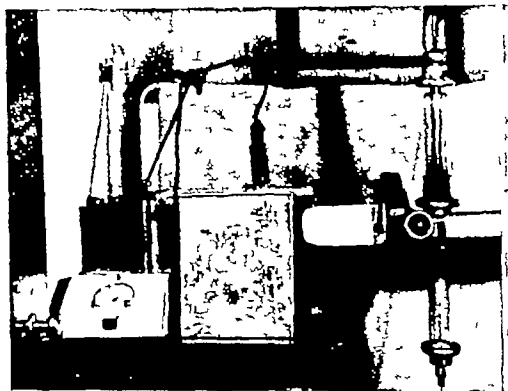


Fig 1 Arrangement of tube, phantom, and ionization chamber (The registering instrument to the left of the phantom was placed in the control room at the time of the experiments)

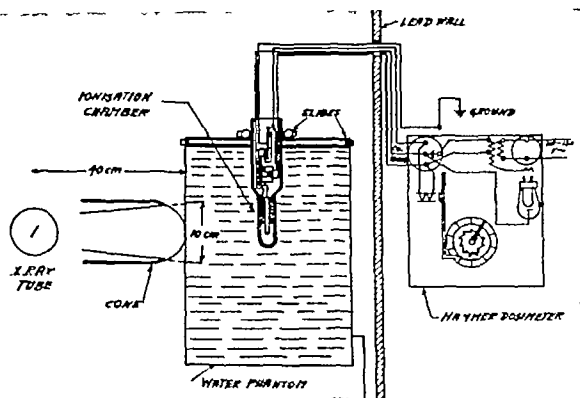


Fig 2 Diagram of Hammer dosimeter mounted on the water phantom

tion of the diaphragm, placed either near the tube or near the phantom, the isodose curves would change in a way characteristic of each particular arrangement.

Only four conditions were constant in all the measurements made heretofore: (1) The angle at which the central ray struck the surface of the water phantom always remained at 90 degrees, (2) the surface of the phantom was always level, (3) the phantom was large enough to guarantee the fullest effect of the scattering, and (4) the medium in the phantom was

ferent shapes if one or all of the four above-mentioned factors are varied. They will, then, more closely approach conditions with which we have constantly to deal in our daily routine of radiotherapy. It is rather astonishing that this field has not been investigated to a greater degree, as it is obvious that such investigations will help to eliminate inaccuracy in dosage compilation.

In composing a treatment plan for a patient, the author has always felt that it was incorrect to apply the isodose charts commonly in use to the circumference of the body if the angle was other than 90 degrees, if the surface of the body was

<sup>1</sup>Read before the American Congress of Radiology, at Chicago, Sept 25-30, 1933

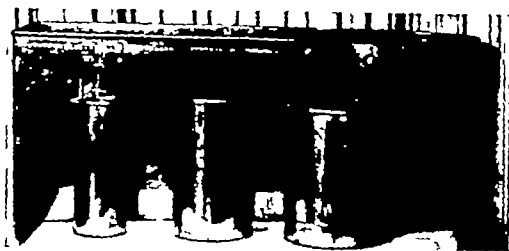


Fig 3 The phantoms used in the experiments were made of 1 mm aluminum

curved, if the volume of the part radiated was small, or if the rays had to pass through media of different density, such as human tissue and gas. In such instances, the intensity in the depth must be lower than the intensities indicated by the present isodose charts.

#### TECHNIC

It is the scope of this paper to cover variations in the relation of central ray and body surface, even or curved, and the decrease of intensity in objects smaller in volume. All other conditions, such as voltage, distance, size of field, filter, and position of the diaphragm, remain unaltered. They are as follows: 180 K V constant potential, 4 ma, 0.8 mm copper plus 1.0 mm aluminum filter (in addition to this, 1.0 mm aluminum comprising the wall of the tank), 40 cm FSD, and a  $10 \times 10$  cm field with a Holfelder cone. The use of a cone gives the same effect as if a diaphragm were placed near the surface of the phantom. The measurements were taken with a Hammer dosimeter made by Mueller, of Hamburg. The tube was a water-cooled Metalix. The central ray had a horizontal direction, and entered the side of the phantom at certain angles through its wall of 1.0 mm aluminum. By means of an arrangement of slides, the ionization chamber could be placed at any desired point within and without the beams of rays inside the phantom (Figs 1 and 2). As the diameter of the chamber did not permit its center to be placed less than 1.3 cm below the surface, all measurements on the sur-

face and at 1 cm depth were made on a paraffin phantom. Comparative measurements were made with the aluminum close to the paraffin and placed with the other filters. The difference was noted and the other measurements corrected accordingly. This arrangement did away with the building of a leak-proof sliding shutter through which the ionization chamber could be introduced and placed at liberty in any desired position. Furthermore, phantoms could be constructed in different shapes with curved walls. For this reason, five phantoms were made: one rectangular ( $25 \times 30 \times 60$  cm), one of oval shape ( $34 \times 22$  cm, corresponding to the shape of the average cross-section of the human body), and three of circular shape with radii of 10 cm, 7.5 cm, and 5 cm, respectively (Fig 3).

#### MEASUREMENTS ON THE EVEN SURFACE OF THE PHANTOM, AT 90, 75, 60, 45, AND 30 DEGREES

If a treatment plan requires the application of a  $10 \times 10$  cm field at 40 cm distance on an even surface at an angle of 45 degrees, it appears, at first sight, that the order could be interpreted or executed only in this way. However, on closer examination, a discrepancy in distance is evident, if the 40 cm are measured from the focus to the middle or to the point of the field which is nearest to the tube, a difference in distance of 1.8 cm (Figs 4 and 5).

It is the more accurate procedure to measure to the middle of the field, for there is only a small overdose at the side nearer the tube. No point of the field receives 100 per cent, if the 40 cm are measured to the edge of the field nearest the tube. The reason for this is that the surface intensity is considerably less toward the side than in the middle. In addition to this, all other points farther away than 40 cm will receive a dose which is inversely proportionate to the square of the greater distance. Furthermore, one may be inclined to map out a  $10 \times 10$  cm field on the body surface, using protective material

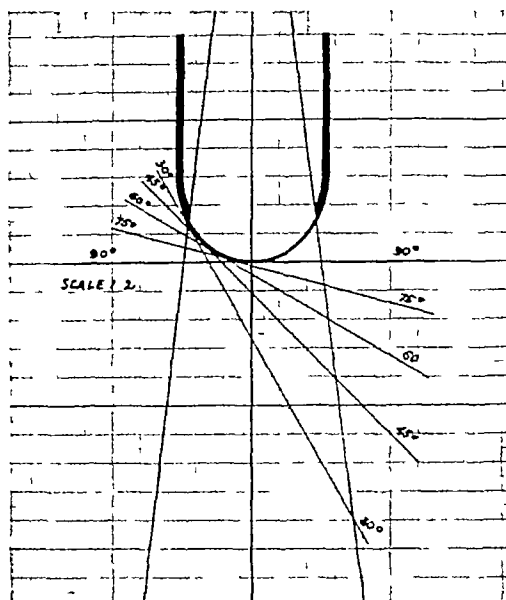


Fig 4 Relation of curved bottom cone to the surface of the phantom at different angles. Note that the distance from focus to middle of field, and that the size of the field increases with tilting of the cone to smaller angle

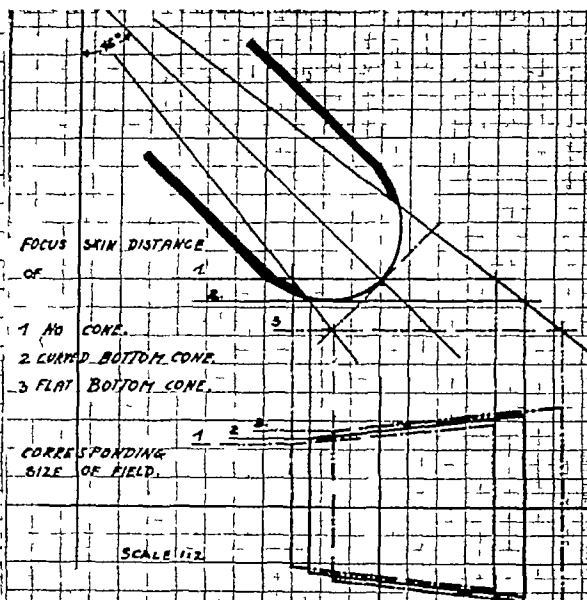


Fig 5 With the tilting of the cone, the distance, as well as the size of field, increases accordingly, and requires additional exposure of from 5 to 20 per cent

The area of  $10 \times 10$  cm should be measured at 90 degrees from the central ray rather than on the surface of the body. It projects itself on the body in the shape of a trapezium, with an area of 141 sq cm, if measured from focus to the middle of the field. If measured from the focus to the edge of the field, it is 198 square centimeters. The latter measurement cannot be avoided if one uses a cone with a flat bottom, as the distance is fixed by the cone.

The only way to overcome these variations is to compromise on a cone with a curved bottom, such as has been devised by Holfelder, and which I have used in my experiments. The curve should be of such shape that it gives the true distance in the middle of the field. Somewhat to compensate for the decrease in intensity toward the side, the FSD is less than 40 cm at the edges of the cone.

The isodose curves obtained at a 90-degree angle do not in any way deviate from those obtained by Holfelder, Glasser, Weatherwax, *et al*. With the decrease of the angle between central ray and surface

a greater distortion of the usually pear-shaped curves toward the far side of the field can be noticed in the depth (Figs 6 to 10). At first sight, one might expect the penetration to be better at the near side from the axis of the beam, but as the intensity of the rays entering at the far side is reduced only by the distance, this more than compensates in depth value for that which has been lost through penetration of water and additional scattered radiation on the other side. This is most evident on the 45-degree chart. The 30-degree chart shows such an extreme distortion and such a poor depth dose that we may arrive at the conclusion that it is impractical to apply a field at such an angle on a rigid surface, where there is no possibility of improving the intensity and distortion by the use of compression.

It is well known that the intensity of radiation on a given field is highest at the middle, and decreases gradually toward the sides of the field. If, therefore, the treatment is given at an angle, the time of exposure must be increased to compensate for this loss of intensity, as well as for



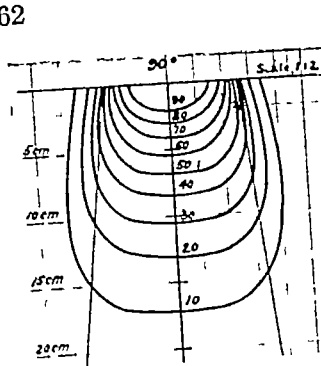


Fig 6

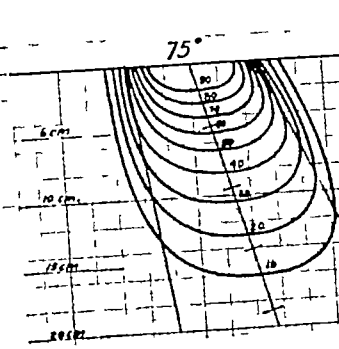


Fig 7

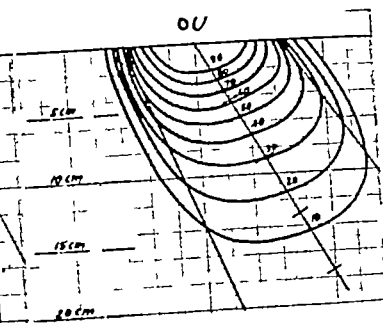


Fig 8

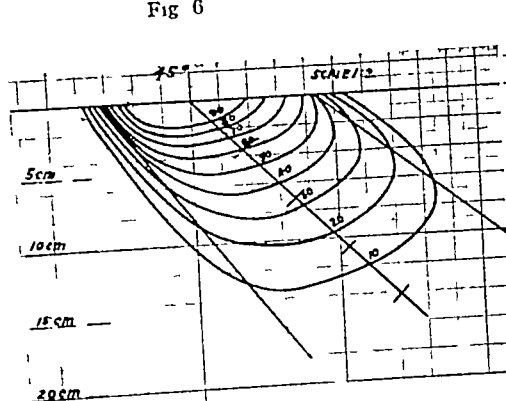


Fig 9

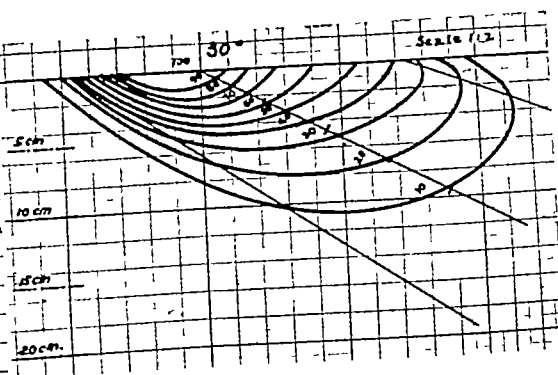


Fig 10

Figs 6, 7, 8, 9, and 10 With the increase in the tilting, the isodose curves suffer a distortion, which at 30 degrees is so great that the use of such a field becomes impracticable, as the actual percentual depth dose is very small

the loss sustained by the increased distance At 60 degrees, 5 per cent must be added to the ordinary time, at 45 degrees 10 per cent, using a rounded cone If a flat-bottomed cone is used, these figures must be doubled It is obvious that they are still higher when a cone of larger size, such as a  $20 \times 20$  cm, is used

It need not be mentioned that all these figures apply proportionately to other dimensions of distance and size of field If, however, a field smaller than  $10 \times 10$  cm is given, 10 per cent must be added for the angle as well as another 10 per cent for the smaller field

#### DEPTH DOSES ON CURVED SURFACES

The oval water phantom measures  $22 \times 34$  cm in diameter and corresponds to the average cross-section of the human body The isodoses in the field given at 90 de-

grees over the middle on the flatter side are identical with those taken on a phantom with an even surface (Fig 11) Perhaps a more marked decrease in intensity toward the sides may be noticed, but the intensity in the depth is the same If we apply a field to the side of the oval tank, where the surface is much more curved, and where there is not so much volume to the sides of the beam of radiation, the shape of the curves will adapt itself accordingly by becoming more slender (Fig 12) So long as there is enough volume left beyond the limits of the beam to extract the secondary radiation scattered, which, in turn, helps to build up the intensity in the depth, we shall not observe any decrease in the intensity in the depth This, however, will take place as soon as the oval changes to a flatter shape

On the field at 45 degrees, directed to-

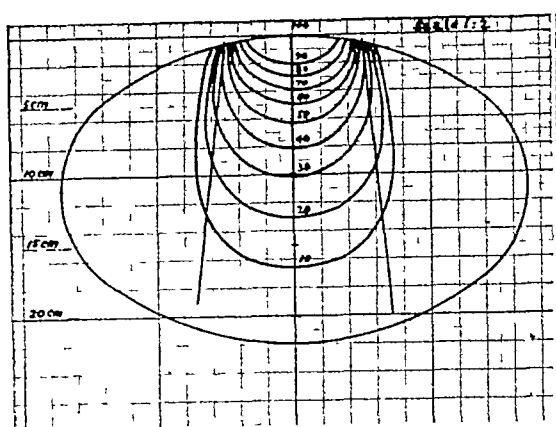


Fig 11

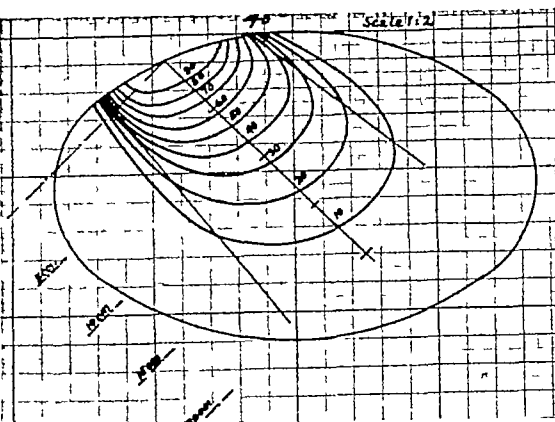


Fig 12

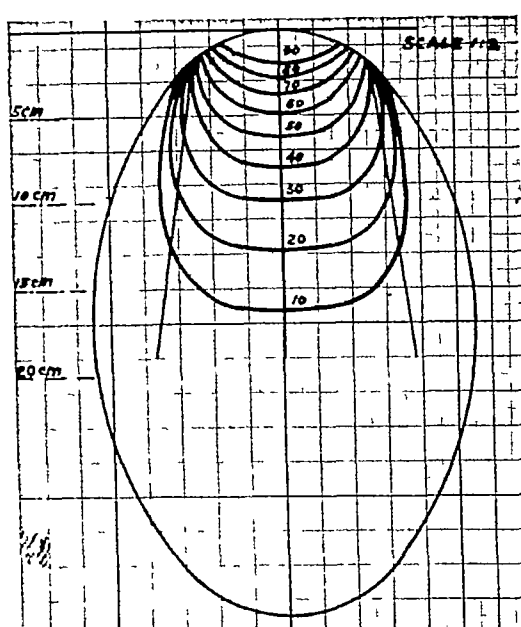


Fig 13

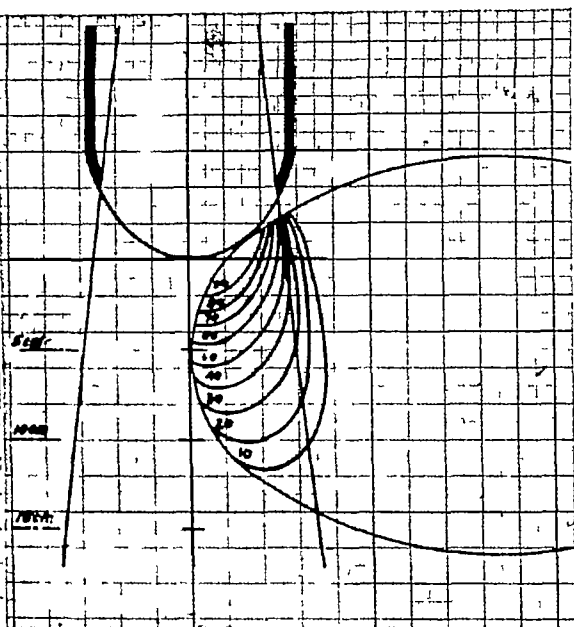


Fig 14

Figs 11, 12, and 13 The oval phantom corresponds to the average cross section of the human body. On the flat side of the oval, the isodose curves show no difference from those in a phantom with level surface. On the pointed side they are somewhat more slender. At an angle of 45 degrees the curved surface of the oval is of distinct advantage to the shape of the curves.

Fig 14 If the rays strike the body tangentially, covering a field  $5 \times 10$  cm, the decrease in intensity is remarkably rapid. The difference with the charts heretofore in use is striking.

ward the middle of the oval tank, we find less distortion of the isodoses than on a similar field applied on an even surface (Fig 13). Apparently it benefits by the curve of the tank, which changes the true angle between central ray and surface to that of an angle wider than 45 degrees.

The loss in effect obtained from the additional back-scattering outside the beam can well be demonstrated on a tangential field (Fig 14). For better demonstration purposes, a beam was allowed to enter an area which, if it were on an even surface, would have a diameter of only  $5 \times 10$  cm.

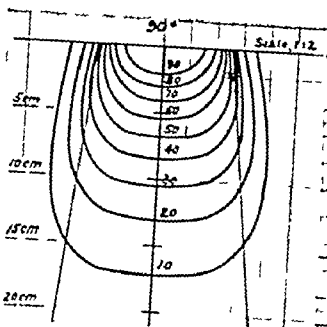


Fig 6

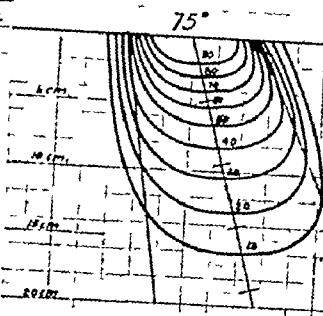


Fig 7

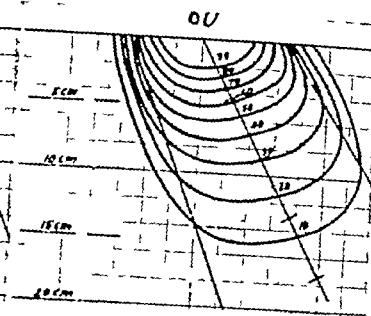


Fig 8

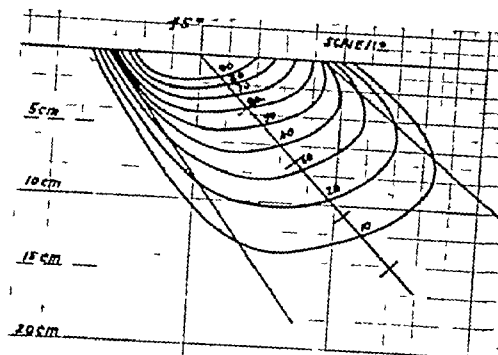


Fig 9

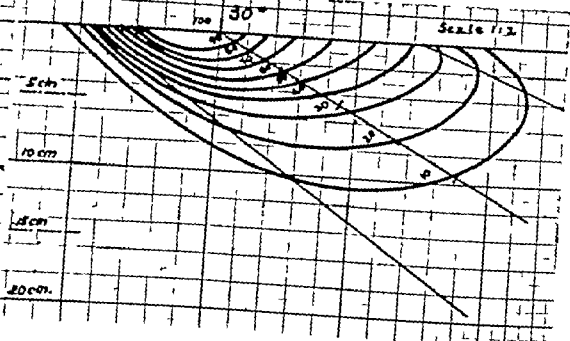


Fig 10

Figs 6, 7, 8, 9, and 10 With the increase in the tilting, the isodose curves suffer a distortion, which at 30 degrees is so great that the use of such a field becomes impracticable, as the actual percentual depth dose is very small

the loss sustained by the increased distance At 60 degrees, 5 per cent must be added to the ordinary time, at 45 degrees 10 per cent, using a rounded cone If a flat-bottomed cone is used, these figures must be doubled It is obvious that they are still higher when a cone of larger size, such as a  $20 \times 20$  cm, is used

It need not be mentioned that all these figures apply proportionately to other dimensions of distance and size of field If, however, a field smaller than  $10 \times 10$  cm is given, 10 per cent must be added for the angle as well as another 10 per cent for the smaller field

#### DEPTH DOSES ON CURVED SURFACES

The oval water phantom measures  $22 \times 34$  cm in diameter and corresponds to the average cross-section of the human body The isodoses in the field given at 90 de-

grees over the middle on the flatter side are identical with those taken on a phantom with an even surface (Fig 11) Perhaps a more marked decrease in intensity toward the sides may be noticed, but the intensity in the depth is the same If we apply a field to the side of the oval tank, where the surface is much more curved, and where there is not so much volume to the sides of the beam of radiation, the shape of the curves will adapt itself accordingly by becoming more slender (Fig 12) So long as there is enough volume left beyond the limits of the beam to extract the secondary radiation scattered, which, in turn, helps to build up the intensity in the depth, we shall not observe any decrease in the intensity in the depth This, however, will take place as soon as the oval changes to a flatter shape

On the field at 45 degrees, directed to-

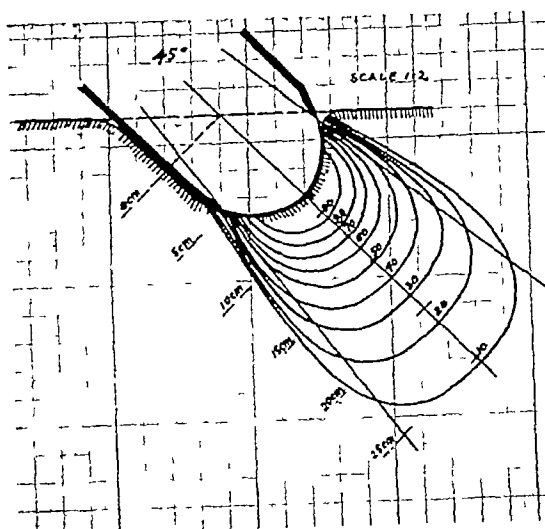


Fig 18

Fig 18 The use of compression will not only bring the lesion closer to the surface, but will also do away with the distortion of the isodose curves, if the treatment is given at an angle

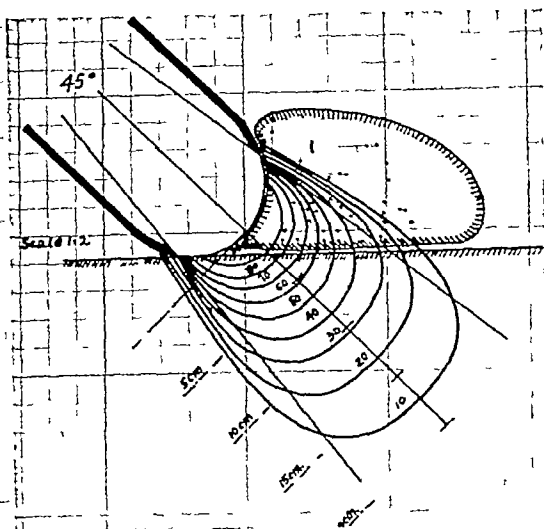


Fig 19

Fig 19 If compression cannot be used, one might fill up the angle between cone and surface with scatter-producing material, such as rice. This is of no value (compare with Fig 9)

tween the size of the field and the radius of the phantom is of great importance in regard to the expected depth intensity. The intensity in the depth is composed of the direct radiation as well as the secondary rays within and from without the direct beam. If there is little or no tissue left outside of the direct beam of rays, there will be no additional radiation from without. Therefore, a depth intensity similar to that in a large phantom can be expected in a cylindrical body, only if its radius is at least equal in length to the length of the corresponding side of the applied field, providing the central ray passes through the center of the phantom. Should the radius be smaller, the intensity of the field must be corrected, as if it were that of a field the sides of which are of the same length as the radius of the part to be rayed.

These conditions must be taken into consideration when radiating an arm, leg or the neck of a patient. The use of the ordinary charts does not, by far, demonstrate the real conditions, and leads to a considerable underdose, which may account for many a failure in the treatment of bone malignancy.

From the amount measured on all the phantoms of different sizes emerging from the other side of the phantom it may be concluded that it is so small (slightly more than 10 per cent on the phantom with the 5 cm radius) that it may practically be neglected on bodies with a diameter larger than 10 cm even when computing the total dose of several fields crossing each other in the middle.

#### THE ADVANTAGE OF COMPRESSION AND ADDITIONAL SCATTER-PRODUCING MATERIAL

There has not been, by far, enough emphasis placed upon the advantage of the use of compression in radiotherapy. By exerting pressure with the cone on the surface of the body whenever possible, the seat of the disease can be brought nearer to the surface, and the intensity within the tumor can be increased to an astonishing degree. The surface radiated is adjusted to the cone, and an angle of 75, or even 60 or 45 degrees, can almost entirely be eliminated. Thus the intensity within the depth retains the shape of the curves from a field applied at 90 degrees (Fig 18).

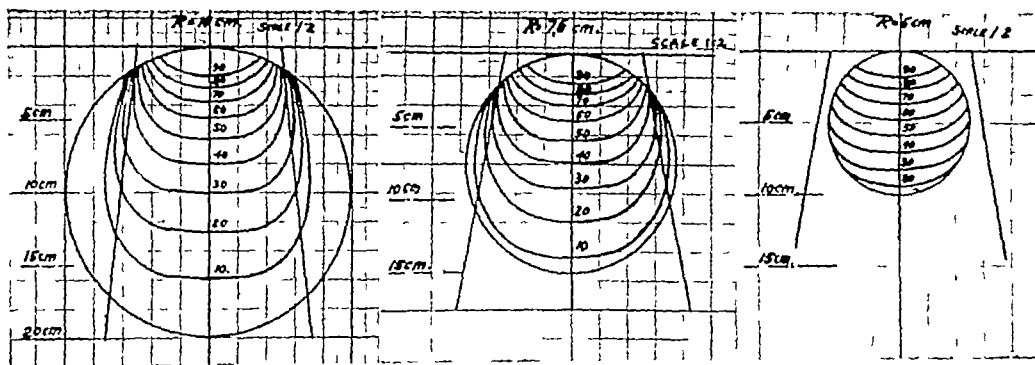


Fig 15

Fig 16

Fig 17

Figs 15, 16 and 17 The proportion between size of field and diameter of radius of the phantom is of great importance. A depth intensity similar to that in a large phantom can be expected in a cylindrical body only if its radius is at least equal in length of the corresponding side of the applied field. Otherwise the intensity must be corrected to that of a field whose sides are equal to the radius of the phantom.

timeters. For this reason one could expect only a distribution of intensity which would correspond to such a field. In practice, such a field is often given with a  $10 \times 10$  cm cone, and an intensity taken for granted, which corresponds to one of a  $10 \times 10$  cm field, in place of a  $5 \times 10$  cm field. The error is obvious. In reality, the ionization chamber measures values which are still lower. Even with the advantage obtained by the use of a curved bottom cone, the penetration is so little that, at 10 cm, only 20 per cent of the superficial dose can be found.

Such a tangential field is used quite frequently, as, for instance, in the treatment of a breast, a shoulder, a head, or a tumor which protrudes from the surface of the body.

The high loss in intensity produced by the smaller volume radiated requires the use of isodose charts which correspond to the true condition. The application, heretofore customary, of the isodose charts obtained at an angle of 90 degrees to the surface of a water phantom of large dimensions obviously leads to a great error in the calculation of the dose.

#### DEPTH DOSES IN CYLINDRICAL PHANTOMS OF DIFFERENT SIZES

This loss in intensity, when a tangential field penetrates through a comparatively

small volume, suggested the investigation of the distribution of the rays in phantoms of more regular shape. For this purpose, I selected three cylinders made of the same material as the other phantoms used in my experiments. They had radii of 10, 7.5, and 5 cm, respectively, and were 30 cm high. In the phantom with the 10 cm radius, the application of a  $10 \times 10$  cm field produced no appreciably different distribution of intensity in the depth, if compared with a similar field on an even surface (Fig 15). On the 7.5 cm phantom, in which the volume of water outside of the direct radiation is less than half of the radius of the phantom in thickness, on each side, the depth dose beyond the middle diminishes rapidly (Fig 16). The 20 per cent curve moves closer to the 30 per cent curve, and the course of the 10 per cent curve is governed by the 20 per cent curve and the outer circumference of the phantom. Only 6 per cent leaves the cylinder.

More striking still is the difference in distribution in the cylinder of 5 cm radius. Here the beam of the  $10 \times 10$  cm field covers the entire circumference of the phantom. The 20 per cent line lies close to the averted surface. Only 13 per cent leaves the tank (Fig 17).

These experiments lead us to the conclusion that the correct proportion be-

from two or more directions. By applying the proper isodose charts on a cross-section map, one is immediately convinced that the distribution of intensity from the fields is far more homogeneous with rice bags than without their use.

The author realizes that his investigations are far from covering the entire field of possible variations, however, this paper is intended to be of stimulus for further research in this line. The more accurate the radiotherapist, in the administration of his treatments, the more can he expect better results and less failures. In this paper attention is drawn to several factors in which inaccuracies have occurred while composing a treatment plan and computing the total dose in the tumor area. Each in itself may appear as only a negligible error, but an accumulation of these and similar errors will unavoidably lead to an irreparable mistake, which may mean death to the patient.

#### CONCLUSIONS

1 To apply the present isodose charts, of a beam striking the surface at 90 degrees on fields to be given at smaller angles, is inaccurate, as it does not correspond to true conditions.

2 With the increase of tilting of the beam to a smaller angle, the isodose curves become more distorted and the percentual depth dose becomes less.

3 It is not economical to apply a field at an angle smaller than 45 degrees.

4 The cone with a flat bottom should be discarded, and one with a bottom curved at the edges should be substituted. This cone will compromise with the errors originating from the difference in distance from the focus to the middle and to the edges of the field, if treatments are given at an angle.

5 In these cases, the surface dose should be increased from 5 to 10 per cent to make up for the additional distance, when using a cone with curved bottom.

When using a cone with a flat bottom, these figures should be doubled.

6 The use of compression should be encouraged, as it not only brings the tumor nearer to the surface, but it also will overcome the distortion of radiation in the depth if the field is given at an angle.

7 When radiating a cylindrical body, the isodose curves are identical with those obtained in a large phantom, if the radius of the cylinder is at least equal to the corresponding side of the applied field, providing the central ray passes through the center of the phantom.

8 The custom of filling up the angle between cone and body surface with secondary ray-producing material should be abandoned, as it results in a smaller depth dose at the seat of the lesion.

9 The use of such material, however, is of great advantage when a part of the body of small diameter is to be radiated, or a field is given tangentially, as the depth intensity is materially increased, and the distribution is far more homogeneous when a cross-firing method is used.

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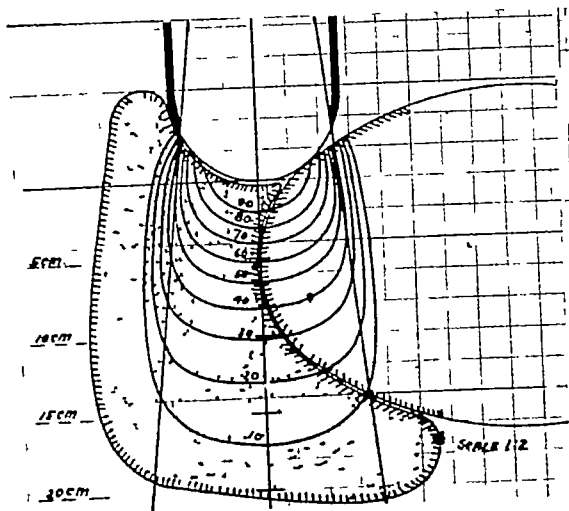


Fig 20

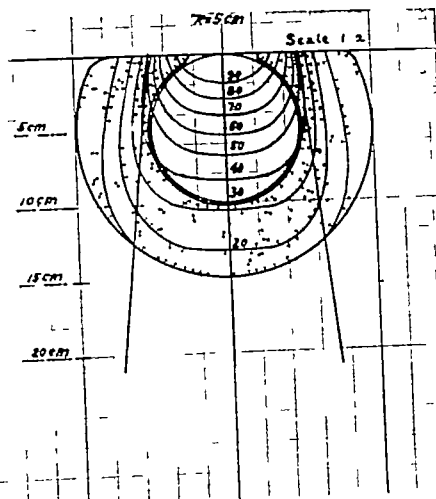


Fig 21

Figs 20 and 21 Building up with scatter-producing material when giving a tangential field, or radiating an arm or leg, will produce a much greater depth intensity, and will enable us to apply the customary isodose charts

In cases in which it is not possible to adjust the surface by compression, as, for instance, on the thorax or head, one might be inclined to expect an improvement in intensity by building up the angle between surface and cone with material producing scattered radiation, such as bags containing rice, talcum, or bolus alba and rice (Fig 19). True, we would obtain an intensity without distortion, but we would do exactly the opposite to that of compression.

The building-up material may, however, be used to great advantage when the body to be rayed is of small volume, such as an extremity, or when a tangential field is to be given. There the scattered radiation from the material will bring the depth dose up to standard, whereas it would have been far less if the extremity were rayed alone. A tangential field on a breast, when covered with sufficient material, will now produce an intensity similar to one in a large water phantom at 90 degrees under the same conditions (Fig 20). If a leg or an arm is embedded in a large enough layer of rice bags, the use of the ordinary intensity charts will show true figures of intensity in the depth. However, the

entire diameter of leg, plus rice bags, must be twice the corresponding length of the field (Fig 21). If rice bags, sufficiently large, are built up around the leg, the size of the field can be enlarged, and by this procedure, a better depth penetration is obtained without exposing a greater area of the leg to the rays, and without changing any other physical conditions of the treatment.

Scatter-producing material was suggested more than ten years ago by Jüngling to even up the surface of the body to be rayed, and to produce a more homogeneous distribution of the intensity. However, Jüngling expects the same intensities in a rectangular box, the sides of which are 10 cm wide, and which contains an arm or leg to be treated, surrounded by talcum or radioplatin, as the intensities obtained in a large water phantom from a 10 × 10 cm field. In a similar manner, he applies the same isodose chart obtained from a water phantom on cylindrical objects having a radius of from 6 to 2 centimeters.

The advantage of using the material in the manner described above becomes more apparent if a breast, arm, or leg is radiated

# COMPOSITE X-RAY FILTERS<sup>1</sup>

By A. MUTSCHELLER, PH D, *New York City*

IN the past, the problem of filtering x-rays for therapeutic purposes has been dealt with rather empirically, copper has been selected as the standard filter mostly for the reason that it is easily obtained in pure form. The semilogarithmic absorption curve indicates the minimum filter thickness above which the use of heavier filters does not result in appreciably larger depth doses. But, in spite of this fact, various attempts have been made to secure better results with heavier filter thicknesses than these minima, as, for instance, with 2, 3, or 4 mm Cu or 0.5 mm Ag.

Many clinicians hope to find a selective action of heavily filtered rays but, unfortunately, the deciding experimental evidence consists in clinical results and, therefore, the answer is not decisive. It appears, however, that several clinicians have found that, for instance, 30 ma filtered through 2.5 mm Cu and 4 ma filtered through 0.5 mm Cu, resulting in approximately the same intensities, produced identical results. This conclusion is entirely in accord with what is to be expected from physical and theoretical considerations, and it is desirable that clinicians convince themselves definitely on that point.

Another direction in which clinical improvements of results are sought is in the use of potentials up to several million volts. From the physical point of view, unless a selective or a specific action of very short wave length rays can be demonstrated, the only advantage that can be expected is a smaller ratio of surface to depth dose, *i.e.*, larger depth doses. But in the extreme case, the largest increase in depth dose obtainable appears to be about 20 per cent (5). However, such radiations penetrate not only the

superposed healthy tissue layers, but also those located beyond on the far side of the tumor. Thus, the intensity and the volume of irradiated healthy tissues in relation to the dose absorbed in the tumor to be irradiated will be considerably larger, and hence the extent of injury to the patient becomes greater in proportion to an expected injury to the malignant tumor. Therefore, if a similar increase of depth dose could be attained by other means, while using radiations generated by moderate voltages, there would be decided advantages, both economic and in possible results, over and above the possibilities from irradiation with extremely high voltages.

One way, however, in which depth doses can be materially increased is by the use of greater distance, another way is through the use of more carefully compounded and adjusted filters. By the two means there seems to be a possibility of approaching the extent of depth dose increase obtainable with, for instance, two million volts.

## A THEORETICAL PART

Absorption curves of x-ray beams comprising the characteristic and the continuous spectrum of tungsten, plotted on semilogarithmic paper, first show a strong bend which gradually becomes less as the absorber thickness is increased. This indicates that the absorption coefficient, which is represented by the slope of the curve, is first very large and then gradually becomes smaller, finally approaching a constant or nearly constant value. This holds for all voltages until a minimum corresponding to 8.86 K V is reached. An absorption curve in tin is similar, but for the same voltage it slopes down more rapidly and the curve continues regularly down to the 29.1 K V.

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.



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radiation It is equivalent to say that below 8.86 K V, copper is quite transparent to x-rays, and that below 29.1 K V, tin shows a selective transparency zone. If tin is used as a filter for a highly penetrating radiation, it effects excellent filtration and has a better homogenizing effect than copper, except that radiations below 29.1 K V would come through very strongly. In quite a similar fashion, if copper is used as an additional filter, it absorbs radiations effectively down to a wave length corresponding to 8.86 K V, but from then on the softer radiations are transmitted rather freely. Therefore, it appears that the soft radiation which normally comes through tin should be effectively absorbed in copper if it is used as an additional filter, and that perhaps aluminum, if used as a third filter, would stop almost completely the 8.86 K V radiation coming through the copper (1). In other words, it would seem that a combination of several metals in proper arrangement would result in a more effective filter for the homogenization of the x-ray beam than would one or the other alone.

From the theoretical point of view, it might appear to be desirable to use filters of an even higher atomic number, *i.e.*, between the numbers 50 and 70, but unfortunately, the elements of this group are so rare and costly that they cannot be considered as available for this purpose. Otherwise the elements in the group from 65 to 71 might be preferable to tin.

However, for radiations produced by voltages above 200 K V, it appears that the heavier atomic metals, molybdenum, tantalum, or tungsten, backed by tin, copper, and aluminum, might be particularly effective in bringing about homogenization of the beam with almost entire absorption of the first order characteristic K lines, and all longer wave lengths. In that case, only the short wave length portion of the continuous spectrum would be retained for application to the patient (2).

## B EXPERIMENTAL PART

Intensity measurements show that 0.13 mm Sn transmits approximately the same radiation intensity as does 0.25 mm Cu (3). In order to arrive at a compound filter with a total absorption value not greater than that of 0.5 mm Cu, attempts were made to determine

(a) the utility of Sn as a filter with the addition of Cu and Al,

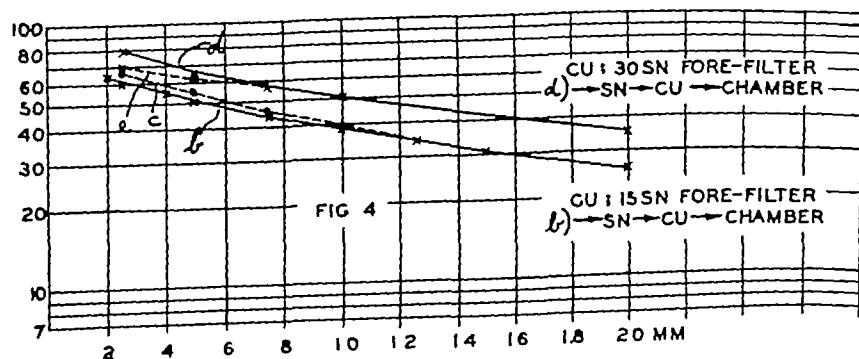
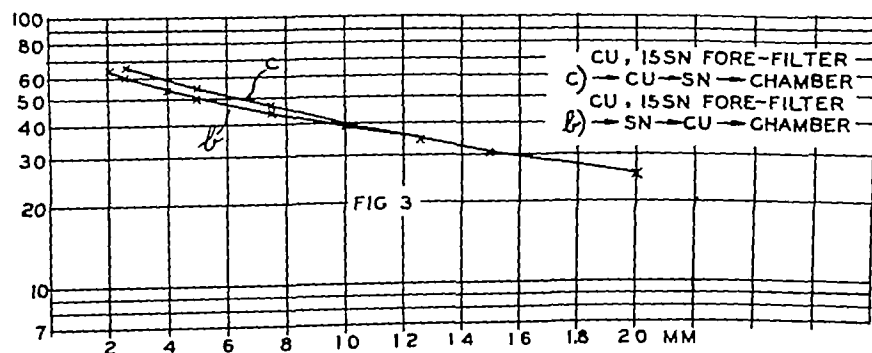
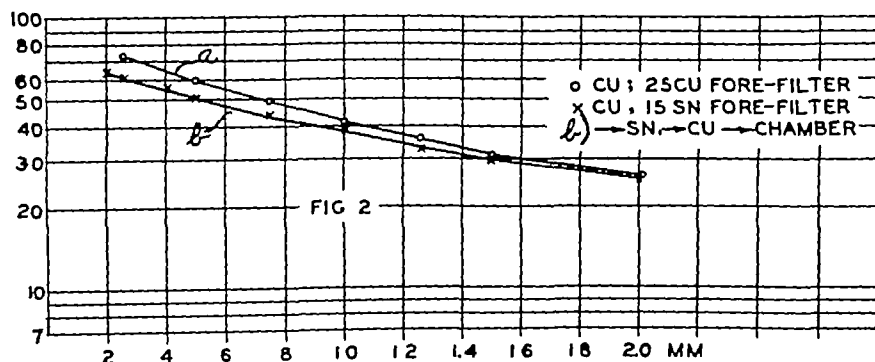
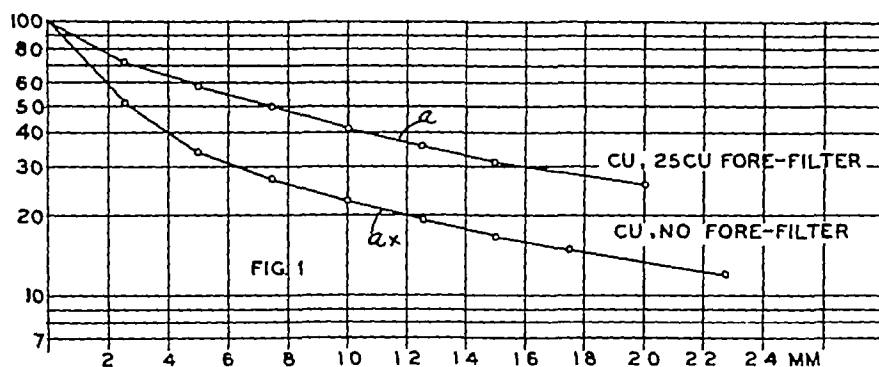
(b) the correct thickness of Sn and Cu to be optimally adequate, and

(c) the correct thickness of aluminum. Absorption curves, spectra, and depth dose measurements were used as criteria to obtain answers to these questions.

1 *Absorption Curves*—The radiation employed throughout was from a Quadroconex uniform voltage apparatus with a ring focus pyrex wall therapy tube operated at 180 K V (determined from the shortest wave length). The radiation intensities were measured with a thimble type ionization chamber connected to a Wulf electro-scope which was calibrated against a standard ionization chamber.

Figure 1 shows two absorption curves measured through increasing thicknesses of copper. The lower curve (a) represents the percentage decrease in various thicknesses of copper, taking the non-filtered radiation from the tube as 100. In the upper curve (b) the radiation transmitted through 0.25 mm Cu as a fore filter was taken as 100. The bend in the upper curve is such that, ordinarily, it would seem that a filter of between 0.5 and 0.75 mm Cu would be necessary to make the radiation sufficiently homogeneous (indicated by the approached straightness of the curve) to give adequate depth doses.

Figure 2 gives the same curve (a) as that in Figure 1, made with 0.5 mm Cu as a fore filter. The lower curve (b) is an absorption curve in Cu with 0.13 mm Sn (tin) as a fore filter. (The 0.13 mm Sn transmits approximately the same total radiation intensity as does the 0.25 mm Cu.) The latter curve (b), by its lesser slope or inclination, indicates that the



radiation It is equivalent to say that below 886 K V, copper is quite transparent to x-rays, and that below 291 K V, tin shows a selective transparency zone If tin is used as a filter for a highly penetrating radiation, it effects excellent filtration and has a better homogenizing effect than copper, except that radiations below 291 K V would come through very strongly In quite a similar fashion, if copper is used as an additional filter, it absorbs radiations effectively down to a wave length corresponding to 886 K V, but from then on the softer radiations are transmitted rather freely Therefore, it appears that the soft radiation which normally comes through tin should be effectively absorbed in copper if it is used as an additional filter, and that perhaps aluminum, if used as a third filter, would stop almost completely the 886 K V radiation coming through the copper (1) In other words, it would seem that a combination of several metals in proper arrangement would result in a more effective filter for the homogenization of the x-ray beam than would one or the other alone

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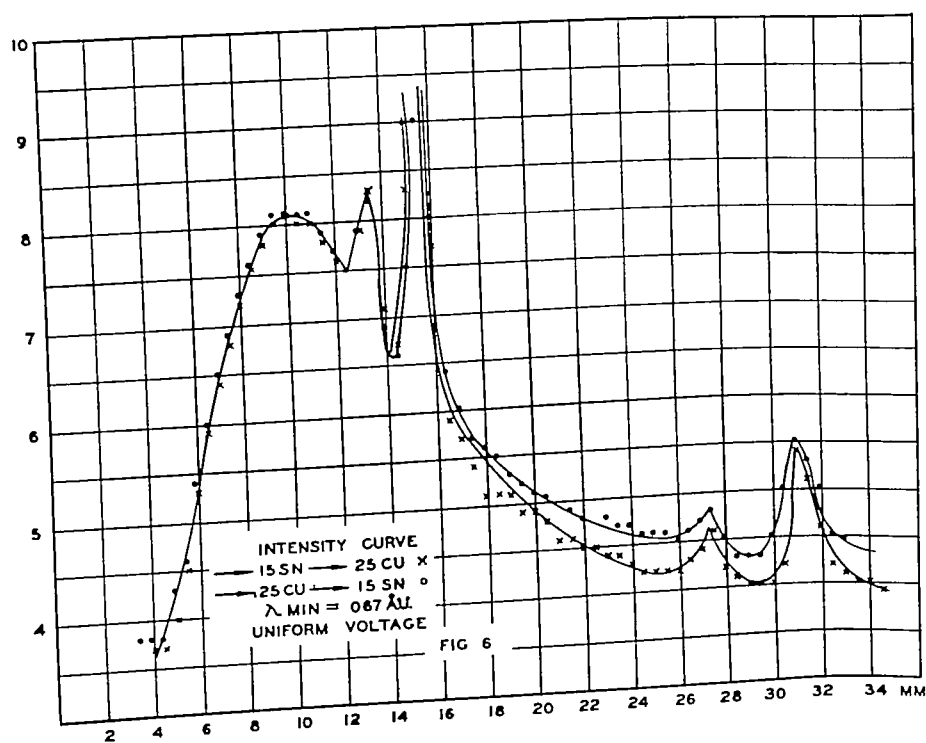
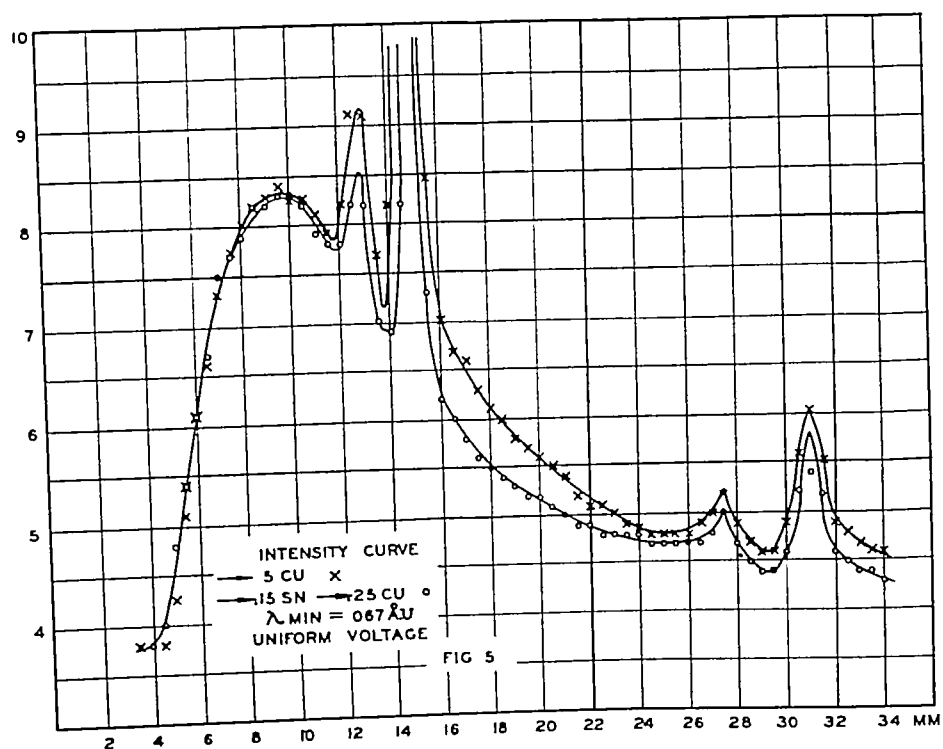
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radiation is slightly more homogenized than that filtered through Cu, and also that, for radiation of this general type, while passing the same intensity, Sn appears to be a better filter than Cu, since it removes a larger portion of soft rays while allowing a proportionally greater portion of penetrating rays to pass through

Figure 3 shows absorption curves of the same radiation in which the filters were interchanged with respect to the direction in which the rays traveled. In the upper curve, however, the rays first pass through the Cu, then through the Sn, and finally reach the chamber. In curve (b) the order of the metals was reversed. The difference in the slope indicates that when the Sn filter is nearer to the ionization chamber, there is more soft radiation contained in the beam than when the Sn filter is nearer to the tube and the Cu filter nearer to the ionization chamber. Therefore, if the filter is placed in the wrong direction, the advantages from it appear to be lost.

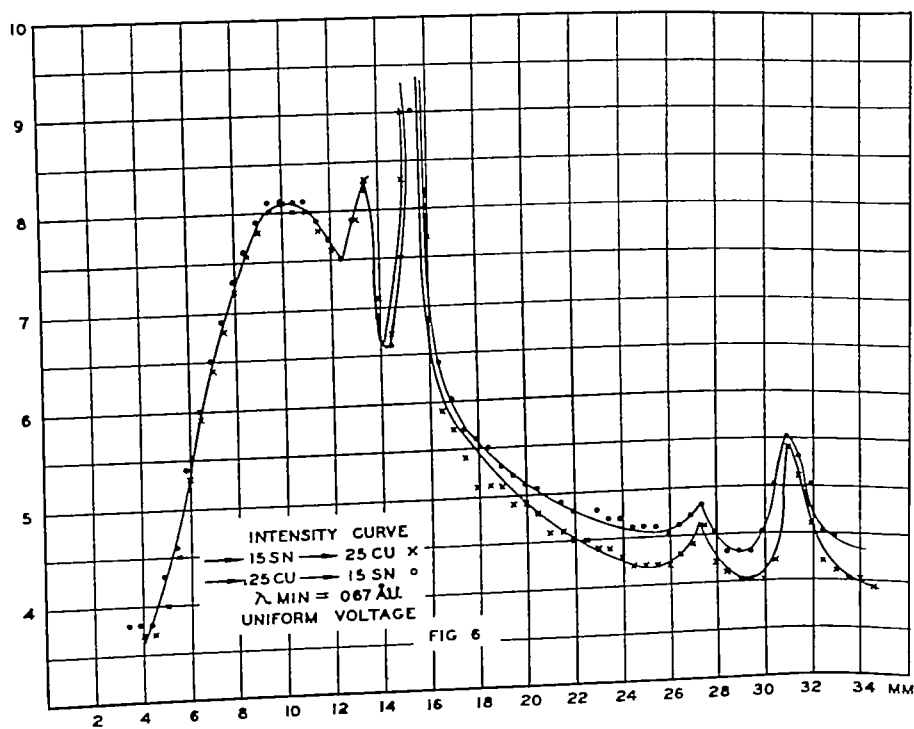
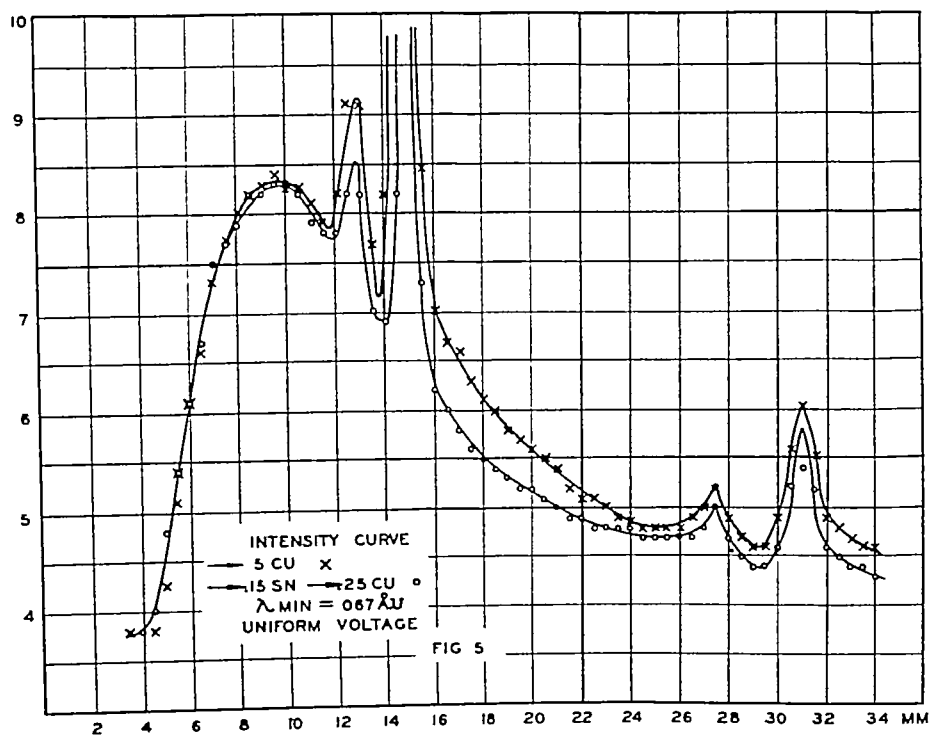
In order to determine whether a filter of 0.13 mm Sn is of sufficient thickness to accomplish the desired result, the curves in Figure 4 were made. Curve (d) was made with 0.3 mm Sn as a fore filter, and curve (b) with 0.13 mm Sn as a fore filter. The two curves are practically parallel and are displaced only in the up-and-down direction, indicating that the general character of the radiation, or its penetrative power, has not been materially changed by the heavier Sn filter, but only that the total intensity has been decreased by the greater Sn thickness.

2 *Spectra*—The differences in the radiation quality, due to various filters and as indicated by the absorption curves in Figures 1, 2, 3, and 4, are more distinctly demonstrated in the spectrograms shown in Figures 5, 6, and 7. The two spectra, which are photometered (4) in each case, were exposed side by side upon one film and identical exposure times were used, except in Figure 7, in which case, for the purpose of obtaining equal intensities, the necessary increase of expo-

sure time for the 0.3 mm Sn fore filter was calculated from the absorption curve.

In Figure 5, the beneficial effect of Sn as a fore filter is distinctly shown in the decreased intensity between the first and second order K lines. It is distinctly noticeable that, on the short wave length side of the first order K lines the intensities are practically identical, and this specifically greater absorption of the wave lengths between the first and second order K lines is of course due to the approach of the specific absorption band in Sn corresponding to 21.1 K V, in which range the absorption coefficients are particularly large. The distinctly greater filtering value of the Sn filter for wave lengths longer than the first order K lines is, therefore, quite distinct. In Figure 6, the effect of reversing the direction of the radiation through the composite Sn and Cu filter is shown in that the first order K lines and all shorter wave lengths come through at identical intensities. Also, in the vicinity of the first order K lines, the intensities are practically identical. Only around the second order K lines is there a noticeable difference, indicating that the soft rays (8.86 K V) from the Sn have reached the spectrograph and are represented in an increased intensity in this long wave length region. Therefore, in the reversed order of the atomic numbers, a composite filter would produce a disadvantageous radiation which would tend to expose the skin to a radiation of rather low penetration, especially if the filter is near the patient.

In Figure 7, the difference between the selected thickness of Sn and a double thickness of the same metal is shown. The slightly increased absorption of the longer wave lengths near the first order K lines is probably just about balanced by the slightly lesser absorption near the second order K lines, and the point in between the K lines probably represents a transition point caused not by the critical absorption band, but rather by the equal absorptive power resulting from a balance between the rate of change of the absorp-



radiation is slightly more homogenized than that filtered through Cu, and also that, for radiation of this general type, while passing the same intensity, Sn appears to be a better filter than Cu, since it removes a larger portion of soft rays while allowing a proportionally greater portion of penetrating rays to pass through.

Figure 3 shows absorption curves of the same radiation in which the filters were interchanged with respect to the direction in which the rays traveled. In the upper curve, however, the rays first pass through the Cu, then through the Sn, and finally reach the chamber. In curve (b) the order of the metals was reversed. The difference in the slope indicates that when the Sn filter is nearer to the ionization chamber, there is more soft radiation contained in the beam than when the Sn filter is nearer to the tube and the Cu filter nearer to the ionization chamber. Therefore, if the filter is placed in the wrong direction, the advantages from it appear to be lost.

In order to determine whether a filter of 0.13 mm Sn is of sufficient thickness to accomplish the desired result, the curves in Figure 4 were made. Curve (d) was made with 0.3 mm Sn as a fore filter, and curve (b) with 0.13 mm Sn as a fore filter. The two curves are practically parallel and are displaced only in the up-and-down direction, indicating that the general character of the radiation, or its penetrative power, has not been materially changed by the heavier Sn filter, but only that the total intensity has been decreased by the greater Sn thickness.

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tion coefficient in Cu and in tin. But on the whole, the balancing effects of the absorption distances near the first and second order K lines are in accord with the characteristics shown in the absorption curve in Figure 4. The result, therefrom, is that a filter heavier than an Sn component of 0.13 mm does not produce any measurable advantage.

Cu, from 0.25 to 2.0 mm thick. The straightening-out characteristic of the curve is entirely in accord with the ab-

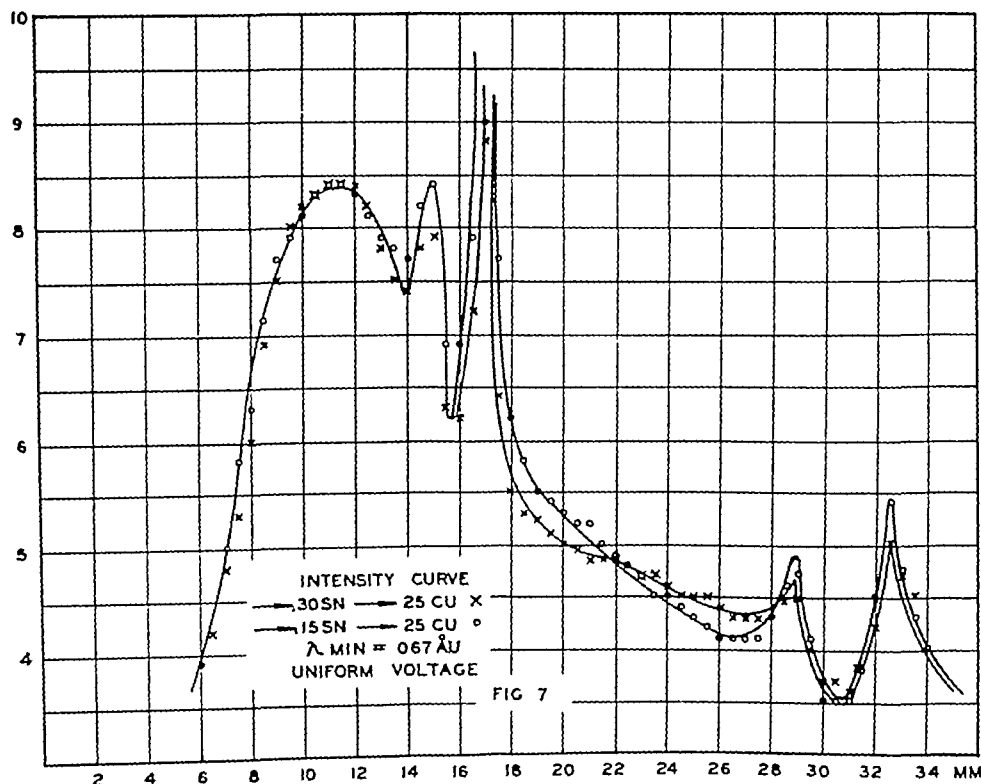


FIG 7

second order K lines are in accord with the characteristics shown in the absorption curve in Figure 4. The result, therefrom, is that a filter heavier than an Sn component of 0.13 mm does not produce any measurable advantage.

**3 Depth Dose Measurements**—Probably the most important practical results are represented in Figure 8, showing the ratio between surface and depth doses. The measurements were made in water, the surface of which was 50 cm from the target and the ionization chamber was, for surface dose measurements, one-half submerged in water. For depth dose measurements it was lowered to a distance of 60 cm from the target without changing any other conditions.

Curve (c) shows the depth dose ratio obtained with various filter thicknesses of

sorption curves, and indicates that with Cu a depth dose better than about 42 per cent is not practically obtainable, even with a Cu filter of 2 mm or more. With the usually employed 0.5 mm Cu, a depth dose ratio of 40.4 is obtained. In curve (a) are given the depth dose measurements with 0.25 Cu + 0.5 Al and increasing thicknesses of Sn (the Sn being nearest to the tube). The slowly increasing depth doses indicated by this curve prove that it is not economically worth while to go beyond 0.13 mm Sn in addition to the above-mentioned metals, and that then a depth dose of 43.2 per cent is obtained. This radiation, which is of approximately the same intensity as that coming through 0.5 mm Cu, therefore, gives a depth dose about 8 per cent larger than 0.5 mm Cu, or about 4 per cent larger than the best

depth doses obtainable with Cu up to 2 mm of thickness

case, can be estimated as equivalent to an increase of about 20 K V. The decreased stress upon the x-ray tube and the appa-

Curve (b) is obtained by using this

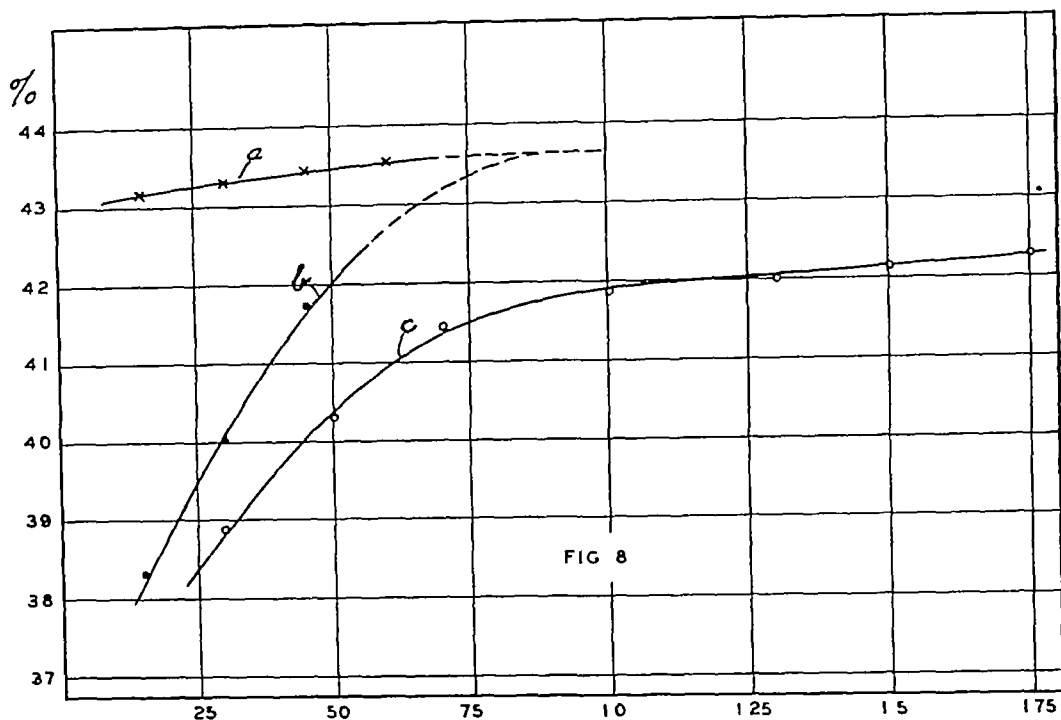


FIG 8

composite filter in the reverse direction, *i.e.*, the rays passing through Cu, then through Sn, and finally through Al. The very low depth doses shown indicate the importance of always using the metals of composite filters in the order of their atomic numbers, the metal of greatest atomic number being nearest to the tube

### C DISCUSSION

Striving for the best possible filter economy is justified because of the considerable saving in the cost of producing therapy radiation doses without any disadvantageous effects. It is further justified by the fact that with a given radiation and improved filtering, a larger dose can be given to a deep-seated mass than is possible with less adequate filtration. The gain from improvement in filtering methods is, therefore, equivalent to an increase in voltage which, in the present

ratus are again advantages obtainable through efficient filtration.

These advantages, however, are assured only if the metal thickness, the purity and density of the metals, and the order in which they are placed relative to the direction of the rays, are correctly selected. It appears that, in particular, impurities in filtering metals, as well as non-definite densities, are factors which very often are neglected, but which are of great importance with respect to compound filters. Each metal should be tested with x-rays as to its absorption, coefficient, and its thickness which is best calculated from the mass absorption coefficient. It is justified to say that, unless all these conditions are fully complied with, the advantages of composite filters may be lost.

A composite filter for radiations between 140 and 200 K V shows distinct merits over a single metal filter, provided

it complies with all the conditions pointed out. For radiations above a 200 K V another composite filter, including an additional metal higher than Sn in the atomic series, *i e*, Ta or W, is to be placed near the tube.

#### D SUMMARY

1 The advantages of using filters consisting of several metals are pointed out.

2 It is shown that the direction of the rays through composite filters must be in the order of the atomic numbers, beginning with those having the highest number.

3 By means of absorption curves, spectrograms, and depth dose measurements, it is shown that composite filters are capable of giving larger depth dose ratios and smaller average absorption coefficients, with a given radiation, than single filters (such as Cu) alone.

4 With a composite filter, a radiation is obtained corresponding to approximately 10 per cent higher voltage than the same radiation filtered through Cu.

5 Two practical filters are recommended—one for radiations from 100 to 200 K V, and the other for radiations above 200 K V.

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# THE SPECTROPHOTOMETRIC ANALYSIS OF THE COLOR OF THE SKIN FOLLOWING IRRADIATION BY ULTRA-VIOLET RAYS<sup>1</sup>

By JAMES R. ROGIN, M.D., M.S.,<sup>2</sup> Fellow in Dermatology, and CHARLES SHEARD, Ph.D.,  
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**A**CCURATE analysis of the color of the skin by use of the spectrophotometric method was carried out some years ago by Sheard (11), Sheard and Brown (12), and Brunsting and Sheard (2, 3). Harris, Leddy, and Sheard (4) used this method in an investigation concerning the erythema and pigmentary changes in the skin following irradiation by roentgen rays. The present investigation was undertaken to determine, through the use of the spectrophotometer, the changes in color which take place in the skin following irradiation by ultra-violet rays.

The details of construction and operation of the spectrophotometer (Keuffel and Esser Color Analyzer), and the principles underlying its use in the analysis of the color of the skin are to be found in the papers by Sheard and his collaborators. By adding a water-cooled cell, Brunsting and Sheard (1) found it possible to examine living tissues spectrophotometrically without subjecting them to changes which might be induced by thermal radiation from the sources of light (two 400-watt lamps) in the apparatus used.

## SPECTROPHOTOMETRIC METHOD AND COLOR NOMENCLATURE

The analysis of color as made from the data obtained by spectrophotometry is a direct and accurate method for the quantitation of color in terms of its fundamental attributes, namely, hue, brilliance, and purity. Much information may be gathered from the plotting of curves showing the relationship between spectral wave length and percentage reflection, and di-

rectly comparing the curves from corresponding areas of skin of different persons. However, if it is desired to describe accurately the color stimulus received by the observer in terms of the color excitation values (red, green, and violet), relative luminosity, and purity, it is necessary to make an analysis of any spectrophotometric reflection curve into its fundamental attributes of color. Such an analysis gives a scientifically correct description of the color as it appears to the eye under noonday sunlight. By suitable computations (12) the spectrophotometric data may be converted so as to express these characteristics of color in universal values.

The brilliance, or relative luminosity (often spoken of as brightness, tint, or value), defines the proportion of the total amount of standard white light which the material under test is capable of reflecting. In this manner, the brilliance of the material may be classified as equivalent to some member of a series of grays, of which black and white are the extremes.

The fundamental hue or dominant wave length refers to that attribute of color by which it may be classed as reddish, yellowish, greenish, or bluish. The hue depends on the wave length only.

The purity or saturation of a color defines the degree of hue which any color possesses. This attribute expresses the vividness or distinctness of a color, and defines how red or how yellow, and so forth, a color is. The Committee on Colorimetry of the Optical Society of America has discussed these and related subjects in complete detail, and for further details reference may be made to its report (14).

## THE SPECTROPHOTOMETRIC ANALYSIS OF THE COLOR OF THE SKIN

In normal subjects Sheard (11), and Sheard and Brown (12), found that the

<sup>1</sup> Abridgment of thesis submitted by Dr. Rogin to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Dermatology. Work done in the Division of Physics and Biophysical Research. Submitted for publication Feb. 12, 1934.

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dominant wave length, purity, and percentages of red, green, and violet excitation values, respectively, remained fairly constant. The value for relative luminosity varied according to the amount of pigment present in the skin. Subjects with much pigment in the skin reflect less light than those with little pigment in the skin. Thus the values for relative luminosity in the skin of a negro will be low, while they will be much higher for the skin of a blond individual. The values of the relative luminosity for the skins of brunets of the white race fall between those for the blond and the negro. Variations in the amount of pigment do not affect either the dominant wave length (which is usually in the region of spectral yellow, 590 millimicrons) or the value for the purity or saturation (which is approximately from 40 to 50 per cent). Brunsting and Sheard studied the color factors of the skin of various races, including whites, negroes, Chinese, and Indians, and found that they differ chiefly in the amount of pigment which they possess. The amounts of pigmentation may be taken as the reciprocals of the values of the relative luminosities. These relative luminosities varied from 46 per cent in the blond to 7 per cent in the negro. In all cases, the values for dominant wave length and purity of the color of the skin of the different races were approximately the same.

Brunsting and Sheard also studied the part played by the superficial blood in the color of the skin. By comparing the reflection curves from the skins of living subjects with postmortem specimens from which the blood had been removed, they attributed the zones of decreased reflection which they found in normal skin in the regions 540 and 580 millimicrons to the presence of blood in the superficial capillaries, since these absorption bands correspond to those given by oxyhemoglobin. They also found that when there is an increase in the quantity of blood near the surface of the skin, there is a decrease in the value of the relative luminosity just as there is when the amount of pigment is

increased in the skin. However, in addition to the decrease in the value of the relative luminosity, the increase in superficial blood causes other changes which an increase in pigmentary content does not produce.

When there is an increase in oxygenated blood, there is a shift in the dominant wave length from the normal spectral yellow region of 590 millimicrons toward the orange or red end of the spectrum at from 620 to 660 millimicrons. At the same time there is a decrease in the value of the purity or degree of hue. If there is an increase of venous blood near the surface of the skin, as in cyanosis, the dominant wave length shifts toward the blue region of the spectrum at from 490 to 500 millimicrons.

The results of Brunsting and Sheard indicate that a decrease in the value of the relative luminosity, without an accompanying change in the other two fundamental attributes of the color of the skin, signifies an increase in the pigmentary content of the region under investigation. The relative luminosity values may be used, therefore, as a measure of the pigmentary content of the skin. The percentage of red excitation values serves as an index to the degree of erythema present in the skin. The value of the purity also might be used for this purpose, since the values of the purity usually follow quite closely the course of the red excitation values. However, the use of the red excitation values appears to be more logical when referring to degree of erythema. Harris, Leddy, and Sheard used these values in this manner in their investigation of the erythema and pigmentary change of the skin following irradiation by roentgen rays. We have followed the same procedure in this investigation.

#### EXPERIMENTAL PROCEDURE

The skin of the volar aspect of the forearm was used in these spectrophotometric examinations. This region was selected because of its accessibility, and because

there is practically no hair on the volar aspect of the forearms of most persons (When a great deal of hair is present,

phils, but were entirely free from cutaneous eruptions of all types It was decided to use these patients as subjects

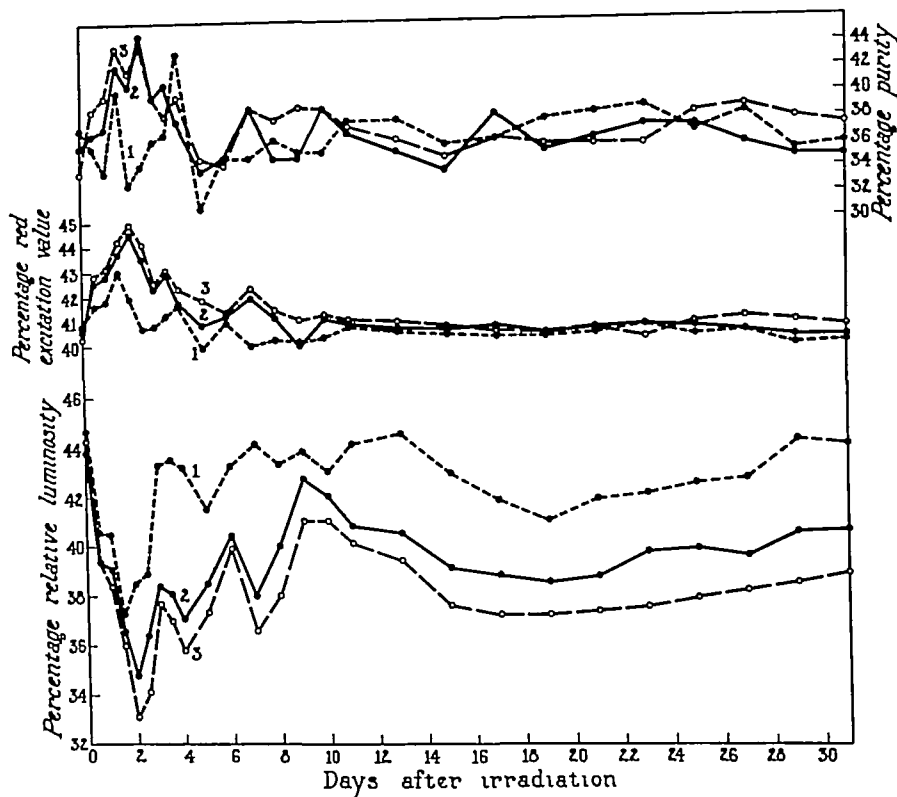


Fig 1 (Experiment 1) Curves of the purity, red excitation, and relative luminosity values Same dosage of ultra-violet radiation Curves marked 1, area moistened with oil of bergamot, curves marked 2, area moistened with 10 per cent alcoholic solution of oil of bergamot, curves marked 3, area directly irradiated

especially if it is dark, the value for relative luminosity is markedly reduced) The subject's arm rested on an adjustable support and was usually in the same position at each examination, that is, at about the level of the heart as he was seated at the instrument A sandbag placed against the arm served to hold it in the correct position before the aperture in the spectrophotometer

The investigation was conducted during the summer, and the subjects chosen were all males who could keep their forearms covered and thus protect the areas under examination from exposure to sunlight throughout the course of the investigations All the subjects had latent sy-

since they had available the time necessary for the daily spectrophotometric examinations, as they remained at the clinic for antisyphilitic treatment It was felt that neither the presence of syphilis nor the treatment instituted would alter the results of the investigation in any way

Spectrophotometric readings of the skin in each area were made immediately before irradiation Stencils of pliable tin were used to block off the areas to be irradiated, and at the same time to protect the rest of the skin of the arm The size of each area irradiated was 3.5 by 4 cm, and this was large enough to cover the aperture in the spectrophotometer The dosage of ultra-violet irradiation employed previously had

dominant wave length, purity, and percentages of red, green, and violet excitation values, respectively, remained fairly constant. The value for relative luminosity varied according to the amount of pigment present in the skin. Subjects with much pigment in the skin reflect less light than those with little pigment in the skin. Thus the values for relative luminosity in the skin of a negro will be low, while they will be much higher for the skin of a blond individual. The values of the relative luminosity for the skins of brunets of the white race fall between those for the blond and the negro. Variations in the amount of pigment do not affect either the dominant wave length (which is usually in the region of spectral yellow, 590 millimicrons) or the value for the purity or saturation (which is approximately from 40 to 50 per cent). Brunsting and Sheard studied the color factors of the skin of various races, including whites, negroes, Chinese, and Indians, and found that they differ chiefly in the amount of pigment which they possess. The amounts of pigmentation may be taken as the reciprocals of the values of the relative luminosities. These relative luminosities varied from 46 per cent in the blond to 7 per cent in the negro. In all cases, the values for dominant wave length and purity of the color of the skin of the different races were approximately the same.

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The skin of the volar aspect of the forearm was used in these spectrophotometric examinations. This region was selected because of its accessibility, and because

red excitation was the highest, or forty-seven hours after irradiation. With several lesser secondary drops, the curve then

the value for red excitation. Also the curve for relative luminosity was rhythmic (wave-like), with low points forty-seven

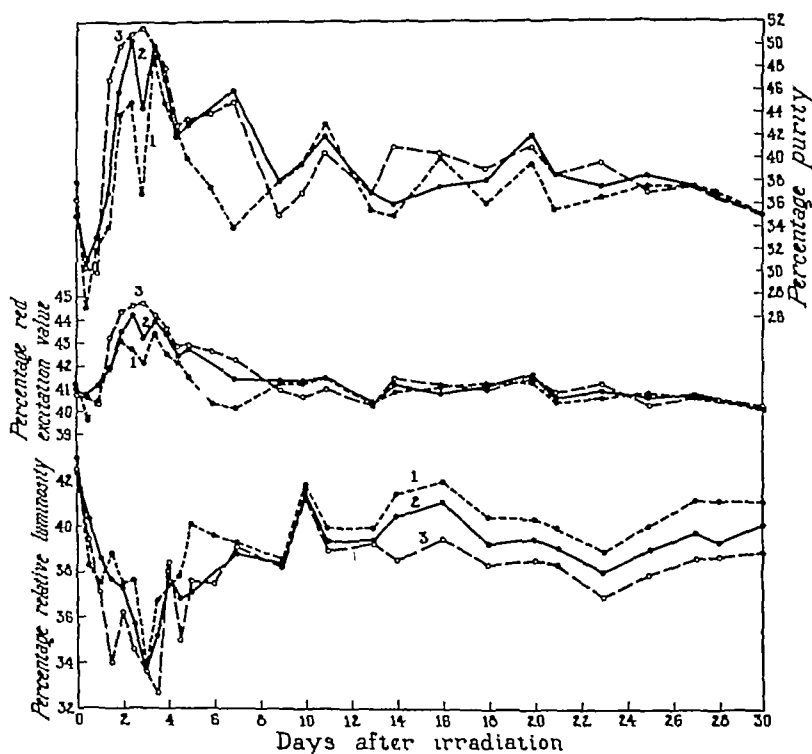


Fig 2 (Experiment 2) Curves of the purity, red excitation, and relative luminosity values. Same dosage of ultra-violet radiation. Curves marked 1, area moistened with oil of bergamot, curves marked 2, area moistened with 10 per cent alcoholic solution of oil of bergamot, curves marked 3, area directly irradiated.

gradually rose until the ninth day, after which it declined steadily until the nineteenth day, this marked the beginning of a gradual rise in value which persisted until the end of the investigation.

The control area, not treated with oil of bergamot, but exposed directly to ultra-violet radiation, revealed a greater increase in red excitation values than occurred in either of the other two areas. This curve was also crisis-like, with its highest point forty-seven hours after irradiation and with secondary peaks on the seventh, tenth, twenty-first, and twenty-seventh days after irradiation. As in the two areas previously studied, the curve for the purity value again followed closely

hours after irradiation (when the value for red excitation was the highest), and with other low points four, seven, and nineteen days following irradiation. From the nineteenth day to the conclusion of the investigation on the thirty-second day the value for relative luminosity increased steadily.

The values for green excitation units changed but little throughout the course of the entire investigation, whereas the values for violet excitation bore somewhat of a reciprocal relationship to those for the red, that is, when the values for red were high, the values for violet were low, and *vice versa*. The dominant wave length varied between 582 and 593 millimicrons. In most instances the value of the domi-



been found to produce moderate erythema in normal skin

The next spectrophotometric reading ordinarily was made about six hours after irradiation. By this time erythema usually had appeared. Readings were then made twice daily for the next five or six days, then once a day for the next week or ten days, and finally every other day for the remainder of the tests. The spectrophotometric readings were continued from four to five weeks.

Three areas of skin of each patient were exposed to ultra-violet radiation. One area was moistened with oil of bergamot before irradiation. A second area was moistened with a 10 per cent alcoholic solution of oil of bergamot before irradiation. The third area, subsequently referred to as the control area, was a portion of the untreated skin. All three areas were then exposed to the same dosage of ultra-violet radiation. It was found that the solutions which were applied before irradiation acted as absorbing media to the ultra-violet rays. The oil of bergamot reduced the dosage to a greater degree than did the alcoholic solution of the oil of bergamot. In effect, then, each patient was exposed to three dosages of ultra-violet irradiation of different intensity.

#### EXPERIMENTAL DATA AND RESULTS

*Experiment 1*—The subject (Fig 1) was a man, aged 63 years, with blue eyes, medium brown hair, and fair skin on unexposed parts. The skin was exposed to ultra-violet radiation from the quartz mercury lamp for two minutes, operated at 125 volts and at a distance of 30 centimeters. Five hours later erythema had appeared in all three areas, but was definitely least marked in the area which had been moistened with oil of bergamot before the irradiation. This difference in degree of erythema was easily perceptible to the naked eye. However, it was impossible to discern any difference between the remaining two areas by visual observation alone. Spectrophotometric analysis disclosed that the greatest erythema, as

measured by red excitation units (Fig 1), appeared in the control area to which no solution had been applied.

The peak of the erythema was reached in the area to which oil of bergamot had been applied twenty-nine hours after irradiation. The curve showing the red excitation values falls rapidly from this point. Schall and Alius found this sharp rise and sharp decline in 39.5 per cent of the cases in which they studied the course of the erythema produced by ultra-violet irradiation. They described it as a "crisis-like" reaction.

As the course of the erythema was followed in this irradiated area from day to day, secondary maxima appeared, the peaks of which were reached on the fourth, eleventh, and twenty-third days after irradiation. The curve for purity values follows closely, but in more accentuated form, that for the red excitation values. The curve for relative luminosity drops sharply immediately after the irradiation, and reaches its lowest point when the value for red excitation is at its peak. As the red value falls, the curve for relative luminosity rises, and, with several lesser secondary drops in value, it continues to rise until the thirteenth day, from which time on it declines steadily until the nineteenth day. From this point the curve gradually rises until the investigation is concluded on the thirty-second day.

The red excitation value for the area to which the alcoholic solution of oil of bergamot had been applied before irradiation revealed an early rise which reached its maximal value forty-seven hours after irradiation. From this point it declined sharply, again crisis-like, but exhibited secondary rises, the peaks of which occurred seventy-seven hours after irradiation, and also on the seventh, tenth, seventeenth, and twenty-third days. As was found in the area previously examined, the purity values again followed closely those for red excitation. The value for relative luminosity in this area dropped sharply from the onset, and reached its lowest point at the time the value for the

oil of bergamot and the alcoholic solution of oil of bergamot had been applied exhibited a distinct decrease seventy-two hours after irradiation, followed by a sharp rise six hours later. Such curves fall into the "double crises" group of reactions which Schall and Alus found with 20.5 per cent of their patients. The red excitation curve in the control area was higher than that in either of the other two, and although the peak was somewhat rounded, it undoubtedly may be classified as indicating a crisis-like reaction. The curves in all these areas were definitely wave-like or rhythmic, with from three to five lesser secondary maxima during the course of the investigation as continued for thirty days. The curves revealing the purity also paralleled the curve for red excitation values. The curves for relative luminosity revealed the initial sharp drops also found with the previous subject. The values gradually rose as the values for the red excitation decreased. Several definite secondary waves in the value of the relative luminosity were noted during the course of the experiment. The highest erythema (red excitation units) occurred in the control area and the lowest relative luminosity value, representing the greatest pigmentation, also occurred in this same area. The lowest erythema value was found in the area to which oil of bergamot had been applied, and it was in this area that the least pigmentation, or highest relative luminosity value occurred. The values for red excitation and relative luminosity for the area to which the alcoholic solution of the oil of bergamot had been applied were between the values for the other two areas.

*Experiment 3*—The subject (Fig. 3) was a man, aged 35 years, with dark brown hair, brown eyes, and very fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for three minutes at 125 volts and 30 cm. distance. The red excitation curves were crisis-like in all three areas. The erythema and pigment values were highest in the control area and lowest in the area to which oil of

bergamot had been applied. The values for the area to which the alcoholic solution of the oil of bergamot had been applied lay between those for the other two areas. The curves for purity, red excitation, and relative luminosity for the three areas were definitely wave-like.

*Experiment 4*—The subject was a man, aged 27 years, with dark brown hair, blue eyes, and moderately dark skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for five minutes at 125 volts and 30 cm. distance. The erythema reaction was crisis-like, and evidence of rhythmicity was present in each curve.

*Experiment 5*—The subject was a man, aged 48 years, with dark brown hair, brown eyes, and fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for four minutes at 125 volts and 30 cm. distance. The curves for red excitation values rose rapidly, and were sustained for approximately one hundred hours before falling. This curve was of the plateau type which Schall and Alus found in 12.5 per cent of their cases. There were only two secondary waves and these also tended to be sustained. The curves for relative luminosity values also revealed division into definite wave-like periods.

*Experiment 6*—The subject was a man, aged 50 years, with dark brown hair, blue eyes, and medium complexion. He was exposed to ultra-violet irradiation from the quartz mercury lamp for two minutes at 125 volts, 30 cm. distance. The curve for red excitation in the area to which oil of bergamot had been applied was crisis-like, and did not rise nearly as high as those in the other two areas. The curves for red excitation value in the other two areas were definitely of the double-crisis type, with the first peak occurring about twenty-four hours after irradiation and the second one about ninety-six hours after irradiation. Evidence of a rhythmic phenomenon was present in all three areas in the curves for red excitation, purity, and relative luminosity.

nant wave length was found to be near 585 millimicrons, and the slight deviations from this value seemed to bear no relationship to changes in the values for the other

nosity, whereas the value for the area to which oil of bergamot had been applied lies between the values found for the other two areas

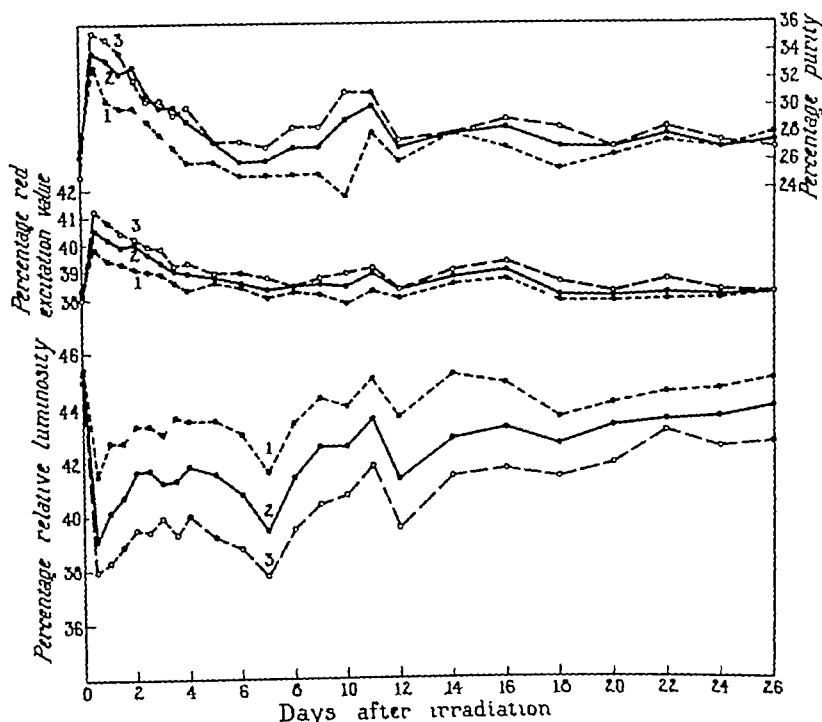


Fig 3 (Experiment 3) Curves of the purity, red excitation and relative luminosity values. Same dosage of ultra-violet radiation. Curves marked 1, area moistened with oil of bergamot, curves marked 2, area moistened with 10 per cent alcoholic solution of oil of bergamot, curves marked 3, area directly irradiated

attributes of color, that is, purity or relative luminosity

Comparing the results from the three areas of the subject examined, it is seen that the greatest erythema (red excitation value) is found in the control area, and that the erythema of the area to which the alcoholic solution of oil of bergamot had been applied was only slightly less. The erythema in the area to which the oil of bergamot had been applied was distinctly less than that in the other two areas.

The curves for relative luminosity, representing degree of pigmentation, bear a reciprocal relationship to the erythema or red excitation values. The control area shows the lowest value for relative lumi-

The results for the remaining subjects examined are quite similar to those obtained in the case of the subject (Experiment 1) which we have reported in some detail. Graphical results of data obtained in certain additional subjects are presented in Figures 2 to 6. It is necessary to comment only briefly on a few of the features revealed by these investigations.

*Experiment 2*—The subject (Fig 2) was a man, aged 53 years, with medium brown hair, blue eyes, and fair skin. This subject was exposed to ultra-violet radiation from the quartz mercury lamp for three minutes, operated at 125 volts and 30 cm distance. The curves for red excitation values for the areas to which

oil of bergamot and the alcoholic solution of oil of bergamot had been applied exhibited a distinct decrease seventy-two hours after irradiation, followed by a sharp rise six hours later. Such curves fall into the "double crises" group of reactions which Schall and Alus found with 20.5 per cent of their patients. The red excitation curve in the control area was higher than that in either of the other two, and although the peak was somewhat rounded, it undoubtedly may be classified as indicating a crisis-like reaction. The curves in all these areas were definitely wave-like or rhythmic, with from three to five lesser secondary maxima during the course of the investigation as continued for thirty days. The curves revealing the purity also paralleled the curve for red excitation values. The curves for relative luminosity revealed the initial sharp drops also found with the previous subject. The values gradually rose as the values for the red excitation decreased. Several definite secondary waves in the value of the relative luminosity were noted during the course of the experiment. The highest erythema (red excitation units) occurred in the control area and the lowest relative luminosity value, representing the greatest pigmentation, also occurred in this same area. The lowest erythema value was found in the area to which oil of bergamot had been applied, and it was in this area that the least pigmentation, or highest relative luminosity value occurred. The values for red excitation and relative luminosity for the area to which the alcoholic solution of the oil of bergamot had been applied were between the values for the other two areas.

*Experiment 3*—The subject (Fig. 3) was a man, aged 35 years, with dark brown hair, brown eyes, and very fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for three minutes at 125 volts and 30 cm. distance. The red excitation curves were crisis-like in all three areas. The erythema and pigment values were highest in the control area and lowest in the area to which oil of

bergamot had been applied. The values for the area to which the alcoholic solution of the oil of bergamot had been applied lay between those for the other two areas. The curves for purity, red excitation, and relative luminosity for the three areas were definitely wave-like.

*Experiment 4*—The subject was a man, aged 27 years, with dark brown hair, blue eyes, and moderately dark skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for five minutes at 125 volts and 30 cm. distance. The erythema reaction was crisis-like, and evidence of rhythmicity was present in each curve.

*Experiment 5*—The subject was a man, aged 48 years, with dark brown hair, brown eyes, and fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for four minutes at 125 volts and 30 cm. distance. The curves for red excitation values rose rapidly, and were sustained for approximately one hundred hours before falling. This curve was of the plateau type which Schall and Alus found in 12.5 per cent of their cases. There were only two secondary waves and these also tended to be sustained. The curves for relative luminosity values also revealed division into definite wave-like periods.

*Experiment 6*—The subject was a man, aged 50 years, with dark brown hair, blue eyes, and medium complexion. He was exposed to ultra-violet irradiation from the quartz mercury lamp for two minutes at 125 volts, 30 cm. distance. The curve for red excitation in the area to which oil of bergamot had been applied was crisis-like, and did not rise nearly as high as those in the other two areas. The curves for red excitation value in the other two areas were definitely of the double-crisis type, with the first peak occurring about twenty-four hours after irradiation and the second one about ninety-six hours after irradiation. Evidence of a rhythmic phenomenon was present in all three areas in the curves for red excitation, purity, and relative luminosity.

*Experiment 7*—The subject (Fig 4) was a man, aged 47 years, with medium brown hair, blue eyes, and very fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for three

this investigation. The curves for the red excitation values for the region to which the alcoholic solution of the oil of bergamot had been applied and the control area were crisis-like, and exhibited high and long-

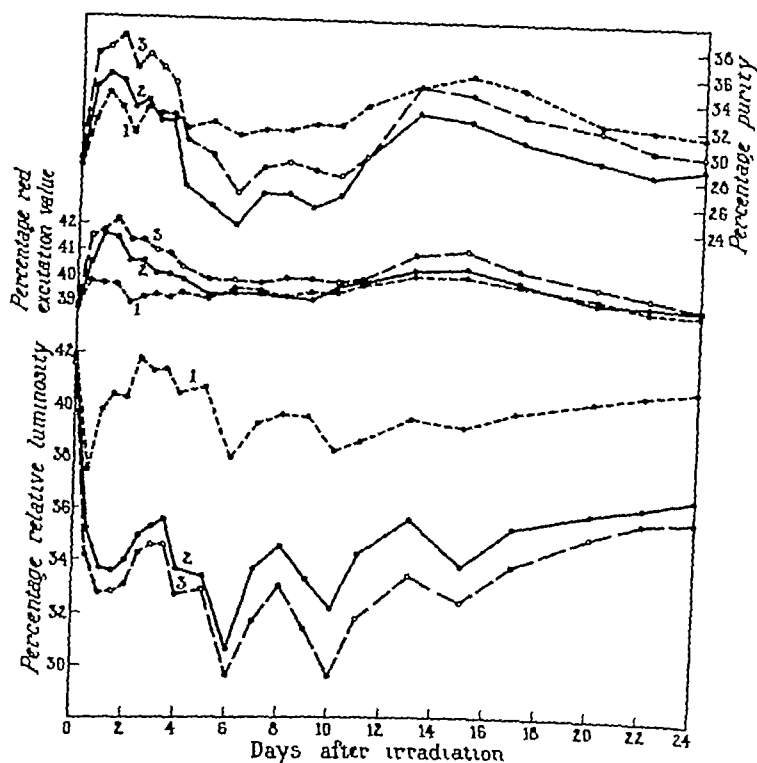


Fig 4 (Experiment 7) Curves of the purity red excitation, and relative luminosity values

minutes, at 125 volts and 30 cm distance. The red excitation curve for the area to which oil of bergamot had been applied was definitely of the plateau type. Secondary waves were present and the final wave which occurred from the tenth day to the conclusion of the investigation reached its maximum at the thirteenth to the fifteenth day. At this point the red excitation value was higher than the original increase obtained immediately after the irradiation. Such exaggerated delayed reactions are quite common following irradiation by roentgen rays (Harris, Leddy, and Sheard), but occurred in only this one area of the twenty-seven which were irradiated during

sustained secondary waves. The rhythmic phenomenon was present in the curves for all three regions.

*Experiment 8*—The subject (Fig 5) was a youth, aged 17 years, with dark brown hair, brown eyes, and swarthy complexion. He was exposed to ultra-violet irradiation on three different occasions. The initial exposure was preceded by applications of oil of bergamot in one area and alcoholic solution of oil of bergamot in a second area. The succeeding irradiations were given without applying solutions to any of the areas. The initial reaction revealed a sharp rise, which reached its maximal value six hours after

irradiation and then dropped rapidly. This rapid fading of the erythema probably is explained by the protective action afforded by the patient's swarthy complexion. A second and larger dose of ultra-

subsequent exposures, since the larger doses gave much smaller erythemic reactions than did a much smaller dose applied to a non-irradiated (normal) part of skin. This observation is in agreement with the

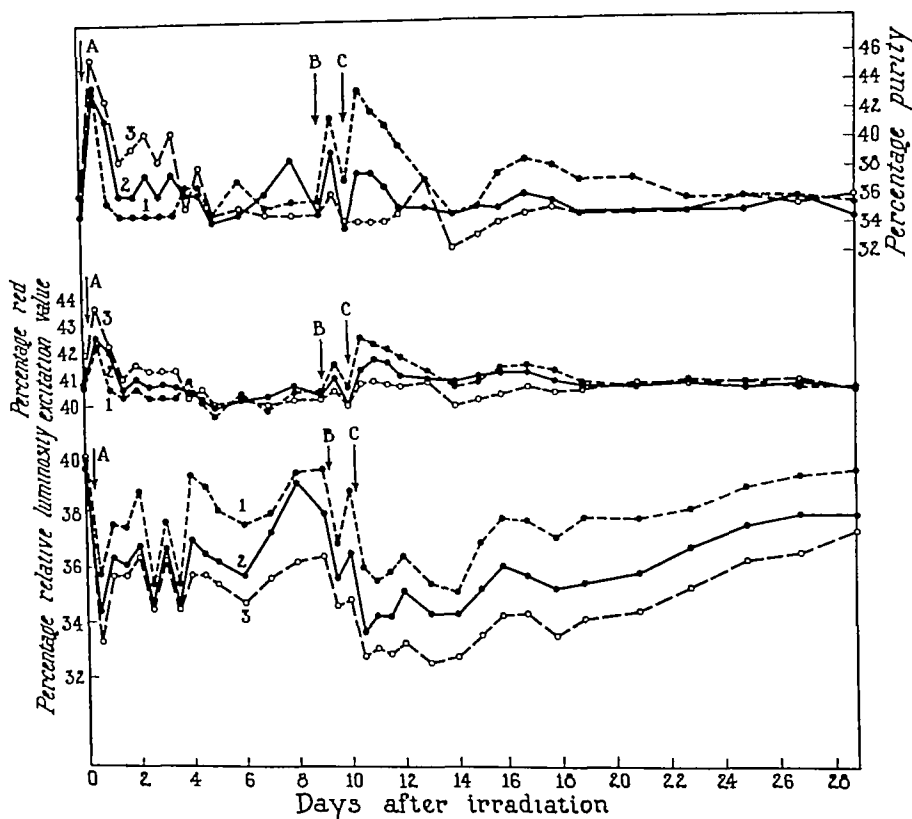


Fig 5 (Experiment 8) Curves exhibiting the values of the purity, red excitation, and relative luminosity. At A, ultra-violet irradiation (125 volts, 30 cm distance for two minutes) preceded by application of oil of bergamot in one area (Curve 1) 10 per cent alcoholic solution of oil of bergamot in another area (Curve 2), and a control area (directly irradiated) (Curve 3). At B, ultra-violet irradiation (125 volts, 30 cm distance for four minutes) only. At C, same as in B, with time of exposure ten minutes.

violet irradiation given on the ninth day produced the highest erythema in the area to which oil of bergamot had been applied before the first irradiation. On the first occasion this area had exhibited the lowest erythema and least pigmentation. A third and still larger dose of ultra-violet irradiation given on the tenth day after the first irradiation again produced only a very slight rise in erythema, as measured by red excitation units. Apparently the pigment produced by the first ultra-violet irradiation acted as a protection against the

commonly accepted statement that normally dark-skinned persons, or those with sun-tanned skins, are not as prone to sunburn as are those not tanned, or blond persons.

*Experiment 9*—The subject (Fig 6) was a man, aged 22 years, with blond hair, blue eyes, and fair skin which was well tanned from previous exposure to sunlight. He was exposed to ultra-violet irradiation in three different areas on the forearms. The curves for the red excitation values exhibited crisis-like reactions in all three

*Experiment 7*—The subject (Fig 4) was a man, aged 47 years, with medium brown hair, blue eyes, and very fair skin. He was exposed to ultra-violet irradiation from the quartz mercury lamp for three

this investigation. The curves for the red excitation values for the region to which the alcoholic solution of the oil of bergamot had been applied and the control area were crisis-like, and exhibited high and long-

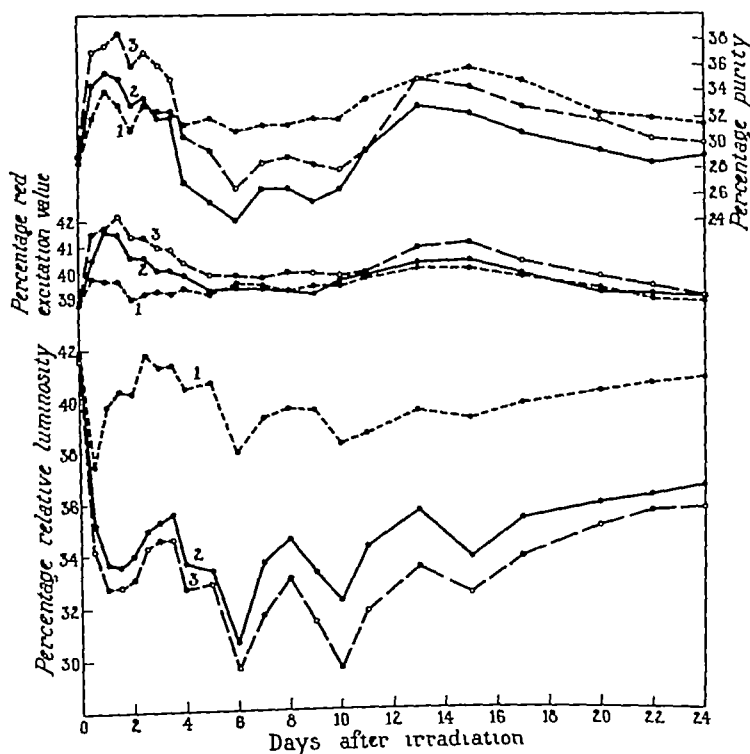


Fig 4 (Experiment 7) Curves of the purity, red excitation and relative luminosity values

minutes, at 125 volts and 30 cm distance. The red excitation curve for the area to which oil of bergamot had been applied was definitely of the plateau type. Secondary waves were present and the final wave which occurred from the tenth day to the conclusion of the investigation reached its maximum at the thirteenth to the fifteenth day. At this point the red excitation value was higher than the original increase obtained immediately after the irradiation. Such exaggerated delayed reactions are quite common following irradiation by roentgen rays (Harris, Leddy, and Sheard), but occurred in only this one area of the twenty-seven which were irradiated during

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irradiation by ultra-violet rays, have been noted repeatedly in the literature, and have been confirmed spectrophotometrically in the present investigation

In general, the course of the values for

luminosity Since there was practically no change in the dominant wave length (hue) in any of the areas studied, the erythema must be due chiefly, if not entirely, to an increase in quantity of blood

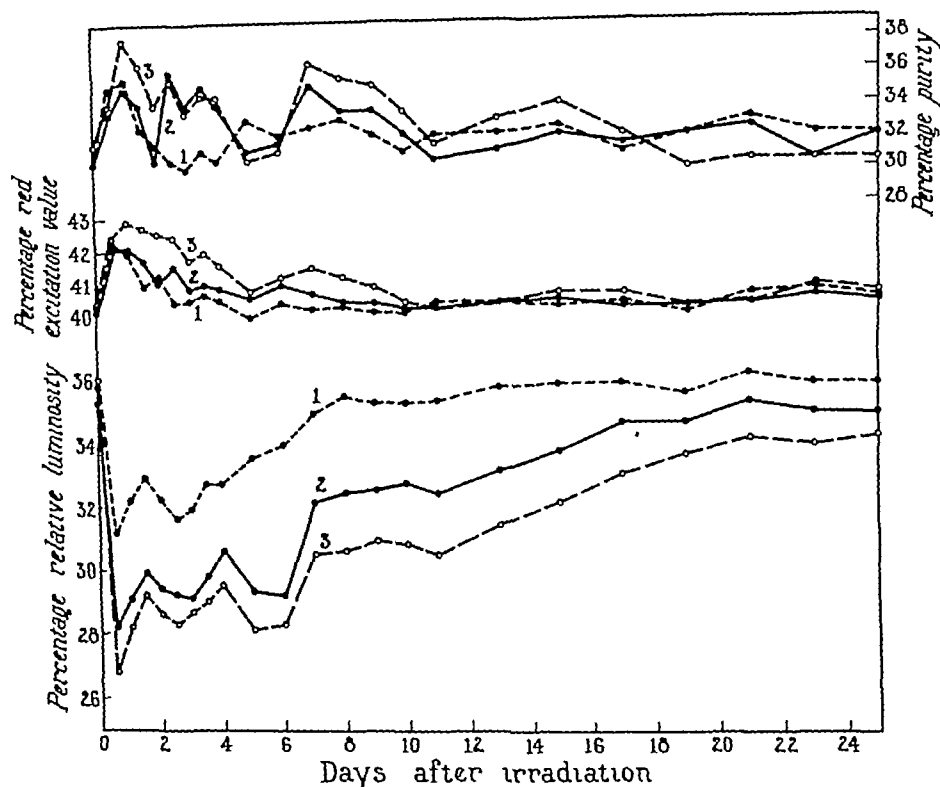


Fig 6 (Experiment 9) Curves showing the values of the purity, red excitation, and relative luminosity. Ultra-violet irradiation (125 volts 30 cm distance) five minutes exposure (Curve 1), eight minutes exposure (Curve 2), eleven minutes exposure (Curve 3)

relative luminosity was also wave-like, but the waves were usually independent of those for red excitation. However, there was an initial sharp drop in the value for relative luminosity, which reached its minimal point at approximately the same time that the value for red excitation was at its maximum. Then, as the erythema faded the value for relative luminosity increased. Brunsting and Sheard have shown that an increase in the quantity of blood in the peripheral vessels would reduce the value for relative luminosity. This probably is the explanation for the initial sharp drop in value for relative

luminosity. The quality of the blood remains unchanged in respect to its oxygen content. This statement is made on the basis of observations by Brunsting and Sheard that a reduction in the oxygen content of the blood, as in congestion (an increased amount of venous blood), causes a shift in hue toward the blue end of the spectrum, whereas an increase in the oxygen content of the blood as in hyperemia (an increased amount of arterial blood) causes a shift in hue toward the red end of the spectrum. Since no change in hue of the irradiated areas occurred at any time during the investiga-



areas The highest value of red excitation was obtained from the area that had been exposed for the greatest length of time, and the lowest value was obtained from the area which had received the least ultra-violet radiation As has been shown in the data obtained from other subjects, the values for relative luminosity were inversely proportional to the values for red excitation Definite evidence of rhythmicity was present in all three areas

#### RHYTHM IN THE COURSE OF ERYTHEMA AND PIGMENTATION

Further analyses of the spectrophotometric data reveal that the initial erythema reaction could be classified according to Schall and Alhus as crisis-like in nineteen of the areas studied, plateau-like in four, and double crisis-like in four

Schall and Alhus (8), and Schall (9) found marked individual variations in the course of the erythema following ultra-violet irradiation However, they noted definite evidence of a wave-like phenomenon, as described by Miescher and others following roentgen irradiation, in 62 per cent of 55 cases studied They found a suggestive wave-like reaction in an additional 14 per cent of their cases, whereas in only 24 per cent this phenomenon was absent The number of waves in each case was variable, but their paper contains a chart revealing from two to three definite waves within the first 134 hours after irradiation

Schwarz believed that a secondary period of latency was not limited to erythemas following roentgen or ultra-violet irradiation He found a wave-like phenomenon in the course of the erythema of mustard oil dermatitis He stated that it is probably also present in other biologic reactions, such as in the tuberculin reaction According to his results, the waves in mustard oil dermatitis occur over a period of hours rather than weeks, as is the case following roentgen irradiation He advanced no evidence for a wave-like phenomenon following ultra-violet irradiation

Pohle studied the skin by means of the

capillary microscope after a single exposure to a medium erythema dose of ultra-violet rays He made observations two, six, twenty-four, forty-eight hours, and two weeks after irradiation At the end of two weeks' time there was no pigmentation, and the capillaries had returned to normal He concluded from his investigations that the effect of ultra-violet irradiation on the capillaries was brief and temporary, and that there was only one cycle

Evidence of a wave-like phenomenon in the course of erythema and pigmentation was present in each of the twenty-seven areas studied in this investigation The individual variations in the time of occurrence of the waves were so great that no attempt has been made to classify the waves according to the intervals of time at which they occurred In this respect the reaction following ultra-violet irradiation is apparently somewhat different from the effects of roentgen irradiation, in which the reaction may be divided into at least three waves occurring at more or less definite intervals of time The same dosage of ultra-violet irradiation was given on only three occasions during the present investigation, and conclusions regarding definite intervals of time for the waves can scarcely be drawn from such a small series There is need for further investigation in this direction, using a constant dosage of ultra-violet irradiation in a large series of cases

The amount of pigmentation which occurred in an irradiated region was directly proportional to the degree of erythema which had occurred in that region This was true only when different regions in the same subject were compared (Experiment 9) Such a statement cannot be made when comparing the erythemas and pigmentation of different subjects A high degree of erythema might result in deep pigmentation of one subject, whereas approximately the same degree of erythema might produce only slight pigmentation of another subject These observations, of the marked individual variations in erythema and pigmentation following

irradiation by ultra-violet rays, have been noted repeatedly in the literature, and have been confirmed spectrophotometrically in the present investigation

In general, the course of the values for

luminosity Since there was practically no change in the dominant wave length (hue) in any of the areas studied, the erythema must be due chiefly, if not entirely, to an increase in quantity of blood

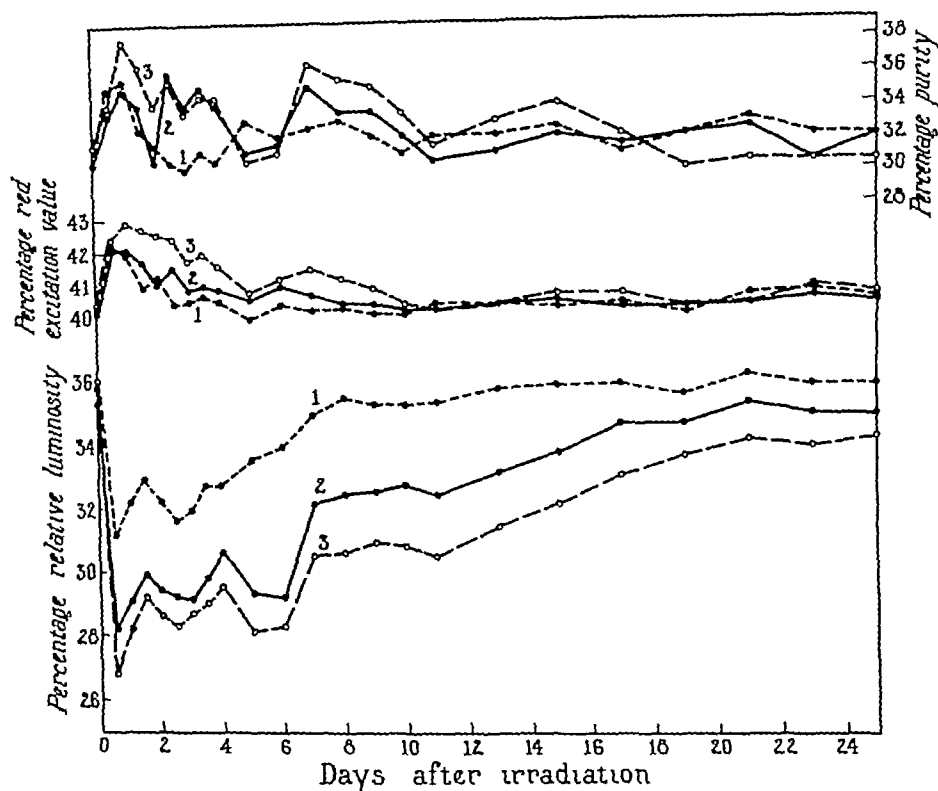


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The difference between libel and slander is that, in libel, the defamation or the defaming statements, etc., must have been made or effected in writing, printing, picturing, caricaturing or by some other visible and (or) understandable manner, while in slander, the offence is committed verbally or by word of mouth only. In libel, *publication is held to have taken place if the libel is seen by one person other than the one libelled*.

If the charges contained in the libel are true, a civil action cannot generally be maintained, but the truth of the libelous matter is no defense at common law, at the same time, conviction generally secures for the defendant a merciful consideration of the court.

If in a civil suit for libel the defendant is found guilty, the amount of the damages is decided by the jury, but in a criminal libel case, the jury has only the authority to acquit or to find the defendant guilty. If found guilty, it becomes the duty of the court to pass judgment and award punishment.

The more recent legislation and decisions in regard to libel have a tendency to limit liability for action to purely false, malicious, and scandalous libels. Truth, if published with good intentions or motives and in pursuit of justifiable ends, is now generally admitted as a good defense, and even motive alone, though the statements may prove to be untrue, is generally admitted as a defense worthy of serious consideration.

The second cause for action, that of trespass on the right of privacy, involves a comparatively new legal principle over which a considerable amount of legal discussion has occurred and concerning which there appears still to be a considerable difference of opinion.

What is termed the right of privacy, on which some of these actions have been based, is the hypothetical right of every person to live his own life, free from public gaze or insight or public interference with his purely personal affairs, except, of course, so far as such public insight, gaze,

or interference may be warranted or occasioned by the public interest or public welfare or by the public nature of the position, office, calling, or profession of the individual so portrayed.

The fact that there is some conflict in the opinions of the courts of several States as to the legal or logical existence of any such right makes it all the more important that we, as directly interested parties, make ourselves better able to discuss the subject and keep informed, insofar as we are able, in regard to the same.

The courts of Georgia, Kentucky, Louisiana, Kansas, Missouri, and Maine have recognized the legality and existence of the right of privacy. New York has a statute in force, specifically recognizing such a right. Courts in Michigan, Rhode Island, New York, and Washington have denied that right. Immediately after the New York court denied the right, the Legislature enacted the statute recognizing it, which is now in force, while in a case in Michigan, the right of privacy was recognized in a suit against a physician wherein a slight stretch of points involved might, and probably would, make this decision apply to this contention.

A case which attracted marked attention at the time is one which was tried in Savannah, Ga.,<sup>4</sup> wherein a child born with a developmental defect of the anterior thoracic wall so that the heart was visible, was taken to a hospital, where it died. The hospital authorities permitted photographs to be made of the body and these were published in the local newspapers. Action was brought against the hospital by the parents of the child, charging a violation of the right of privacy, their "right to have the extrinsic facts of the case kept secret and the child kept unexposed to public gaze and comment." A judgment was rendered against the hospital and it was affirmed by the Supreme Court of Georgia.

Recoveries have been allowed to plaintiffs for violation of their rights of privacy.

<sup>4</sup> *Basemore vs Savannah Hospital (Ga.)* 155 S. E. R. 194

in printing or publishing of their photographs or of photographs of their children without consent in a number of cases, ten of which the writer is prepared to cite

The doctrine that the right of privacy has been indirectly—and should be directly—protected by courts, primarily had its origin in "The Right to Privacy," a paper by Samuel D. Warren and Louis D. Brandeis, published in 1910 in the "Harvard Law Review." This paper has been called a "fountain-head of discussion, comment, criticism, litigation and perhaps even legislation." Since the last sentence was written it has been the cause even of legislation in New York. The authors, in the original article, pointed out that an action of tort for damages lies in all cases for the violation of the right of privacy without showing special damages.

It should be remembered that special damages may be of two kinds. In one instance special damages must be shown before there is a substantive right for action, while in the other, and this is the usual use of the phrase, special damages are additional damages over and above the ordinary loss which the plaintiff has sustained. It is to the first-mentioned instance to which reference as special damages for either libel or slander or the violation of the right of privacy applies.

Regarding this paper, Roscoe Pound, Dean of Harvard Law School, said "What may almost be called the classical example of creative activity is the paper on 'The Right to Privacy,' in which Mr. Justice Brandeis, then at the bar, was a collaborator. A bit of juristic reasoning on the analogy of the legal rights that secure other interests of personality, showing that there was an interest or claim of privacy as a part of personality, and postulating a legal order that secures personality completely, created first discussion, then a conflict of discussions, and finally through decision or statute, a new chapter in the law of torts."

I quote from what appears to be the most celebrated and certainly the most quoted and leading case, that of *Pavesich*

vs. New England Life Insurance Co. "The right of privacy has its foundation in the instincts of nature. It is recognized intuitively, consciousness being the witness that can be called upon to establish its existence. Any person whose intellect is in a normal condition recognizes at once that, as to each member of society, there are matters private and there are matters public so far as the individual is concerned. Each individual as instinctively resents an encroachment by the public upon his rights which are of a private nature, as he does the withdrawal of those of his rights which are of a public nature. A right of privacy in matters purely private is, therefore, derived from natural law."

In the case of which the preceding quotation is a part of the final Supreme Court decision, the insurance company defendant published a recognizable picture of the plaintiff in an advertisement, together with statements purporting to have been made by him. The name of the plaintiff did not appear in the advertisement. The trial court, as well as the Supreme Court of Georgia, held that the plaintiff had cause for action for violation of his right of privacy as well as for libel.

Five States have given the right of privacy a common law standing, namely, Georgia (in 1905 and again in 1924), Kentucky (in 1909 and again in 1912 and 1927), Missouri (in 1911), Kansas (in 1918), and Maine. Louisiana recognized this right under its civil laws in 1905. The States of Michigan (1899), New York (1902), Rhode Island (1909), and Washington (1911), have refused to accept it as a common law right.

The decision in the New York case was decidedly unpopular and was bitterly criticized. As a direct reaction, a statute specifically recognizing the right of privacy was enacted by the New York Legislature within one year after the rendition of the decision. Decisions from Michigan and Washington were severely criticized in "10 Michigan Law Review, 335."

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distinct bases for this decision—the violation of a contract and the violation of the right of privacy. The court considered that if the publication of a photograph of a living person is actionable (and quoted several decisions which of themselves are of no interest here), the same rule should apply to the publication of a photograph of the dead. This case was particularly interesting because it gave to the parents of the dead child the right of action, such right being generally considered to be personal and to die with the individual or person involved. But this court evidently—and wisely—considered that the parents as well as the child had a right of privacy which had been invaded and violated, thus indicating in a clear manner that there are separate rights, one to the child and the other to the parents.

In a New York case, the right of privacy was expressly placed on a property basis by an eminent jurist. While dissenting in the decision against the majority of the court in this case, Judge Gray, of the New York Supreme Court, said, "*I cannot see why the right of privacy is not a form of property*"

#### ABUSE OR VIOLATION OF "PRIVILEGE" BY PHYSICIANS

The basis and theory that clinical photographs, case history records, roentgenograms, etc., are confidential and privileged communications bring up another, and to us a very important, point in connection with this subject. Might not a physician in permitting the publication of the photograph or other likeness of a patient make himself liable for action for damages because of his disclosing confidential or privileged communications in States which have privileged communication laws?

Very few cases appear to have been decided with respect to the extent and nature of a physician's liability for disclosing confidential or privileged communications and with respect to the nature of enforce-

ing that liability. Such cases as have occurred and do exist in the records, are closely associated and combined with the disclosure of information that was libelous *per se*, so that they are not specific

#### CONCLUSIONS

Five State Supreme Courts, having recognized the right of privacy as a substantive right, have rendered decisions to that effect, such recognition being based largely upon the arguments and reasons presented by Warren and Brandeis in the original presentation of the subject.

Contrary to these five States, four other State Supreme Courts have decided to refuse the right of privacy as a substantive right, but one of these States (New York) immediately enacted a statute recognizing that right. It appears that such refusal is based largely upon the lack of precedent and the fact that the injury in such cases is essentially an injury to the senses and feelings, for which the law is supposed not to allow recovery according to the prevailing rule. It is the apprehension by some of the jurists who wrote the decisions that recognition of the right of privacy would result in an enormous amount of litigation.

From the foregoing, it appears to the writer that we, as physicians, should be exceedingly careful not to lay ourselves liable to action for violation of the right of privacy by

- (1) Exhibiting recognizable photographs or likenesses of patients without their written consent,

- (2) Being more than ordinarily careful regarding disclosures of privileged or confidential communications,

- (3) Being exceedingly careful when describing cases, even to our colleagues, so as not to lay ourselves open to action for libel,

- (4) Being careful and cautious to at all times respect what is sure to become

more and more recognized, namely, the right of privacy, and consequently more and more used by the sort of persons who sue members of our profession

With such ordinary circumspection and restraint as we should at all times exercise, none of us will or should be held responsible for any of these torts or civil wrongs

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# PARATHYROIDISM: ITS LATE RESULTS<sup>1</sup>

By MAX BALLIN, M D,<sup>2</sup> and ARTHUR R. BLOOM, M D, *Detroit*

THE history of parathyroidism, from the time Askanazy first mentioned the association of osteitis fibrosa cystica with parathyroid tumor, in 1907, and Mandl did the first parathyroidectomy for osteomalacia, in 1925, to the present, has been thoroughly discussed by Hunter, Barr and Bulger, Camp and Ochsner, Ballin and Morse, and others, therefore, this phase of the subject will not be taken up. These authors have also described the typical clinical symptoms of parathyroidism—localized pain, backache, decrease in height, tumor formation, pathologic fractures, the usual x-ray findings of demineralization, and hypercalcemia.

The roentgenologic findings are (1) General or localized demineralization, (2) mottling of the bones by osteitis fibrosa cystica, usually "generalisata," but also localized at times, (3) deformities of the decalcified bones, (4) formation of larger cysts and giant-cell tumors in the bones, (5) fractures.

A review of a series of cases reveals that some of these various manifestations, which have formerly been classified as clinical entities, should have been diagnosed as cases of parathyroidism.

From a clinical point of view a few types may be distinguished.

1 The vertebral type, in which pain, deformities, osteitis fibrosa cystica, compression fractures, etc., are mostly pronounced in the spine.

2 The type with bone cysts (multiple and monostotic), in which giant-cell tumors and spontaneous fractures occur mostly in the long bones.

3 The infantile type, with chondromas, slipping epiphyses, and fractures.

The beginning of symptoms in infancy is quite significant.

4 The arthritic type, in which the arthritis is the outstanding symptom but other symptoms speak for parathyroid origin.

5 Paget's disease.

This grouping is not a strict one, rather, overlapping between the different types is the rule. For instance, the vertebral type always shows changes in the skull, pelvis, and the extremities. Cysts and fractures are seen in this type, as well as in the second type, and *vice versa*, vertebral changes occur in the second type, and so on.

The generalized demineralization of the skeleton expresses itself on x-ray examination by lack of calcium, the bones have a washed-out appearance. In other instances, there are pin-point areas of decalcification, so that the bones seem to be granular or mottled. This is the roentgenologic expression of the pathologic entity of osteitis fibrosa cystica. Comparison of the plates with those of the same type of bones in individuals of the same age often gives the best judgment as to the degree of decalcification. The appearance of larger cyst formation in the bones and giant-cell tumors naturally shows itself by more or less round long defects in the lime-containing bony substance. At other times, the decalcification is so advanced that the contours of the bones can hardly be distinguished. The lessened lime content makes the vertebrae soft, they become compressed and wedge-shaped from the weight of the body, and the patients are stooped.

This condition injects an interesting factor in the determination of vertebral fractures from a medico-legal, as well as an academic, standpoint. Given a patient who has suffered a spinal injury, the film reveals compressed vertebrae, and we must

<sup>1</sup> Read before the Radiological Society of North America, at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1, 1932.

<sup>2</sup> The death of Dr. Ballin took place in March, 1934.



determine, first if we are dealing with an out-and-out fracture, or, second, if this is a case of parathyroidism with vertebral collapse, but one in which the injury served only to call attention to the diseased spine, or, thirdly, if we are dealing with parathyroidism with soft vertebræ, in which a slight injury has caused a fracture

Osteitis fibrosa cystica has definitely been proved to be due to parathyroidism, both experimentally and clinically. The injection of repeated doses of parathormone in animals has resulted in the typical x-ray and pathologic appearance of parathyroidism. Large numbers of parathyroidectomies have been performed, with recovery of the patient. The bone acts as the storehouse of the calcium for the body. Parathormone, either injected or secreted from a hyperfunctioning gland, removes the calcium from the spongiosa. Hemorrhages may occur in these areas, producing brown tumors and bone cysts characteristic of giant-cell tumors. Giant cells are found on microscopic examination.

#### FATAL CASES

Parathyroidism is recognized by all familiar with this entity to be a very dangerous, and frequently fatal, sickness. The patients die from exhaustion, due to pain and discomfort. Not infrequently decubitus ensues, due to the forced position the patients must assume, for they can hardly find a comfortable posture for weeks and months. In other cases, the deformity of the thorax leads to such diminution of the vital capacity of the lungs that death results from this and also from compression of the heart and large blood vessels (see Case 2). Other cases have been described in which severe vomiting, due to calcium deposits in the intestinal mucosa, etc., led to death. Nephritis, due to such deposits in the kidneys, is contributory to death (see Case 3).

#### AUTOPSY CASE

Case 1. Mrs. M. B., age 35 years. In 1914, the patient developed a swelling

on the left forearm, followed by swellings along the ribs. A cyst formation was discovered in the forearm. Other foci of osteitis fibrosa cystica were found in the legs. The arms and legs were operated upon and the cysts curetted. In 1915, she was unable to walk and had to use crutches. She suffered considerably from pain in the spine and legs. A large fibroid was discovered in 1920. She died, in 1925, from an intestinal obstruction.

Autopsy showed all the bones very much thickened and irregularly deformed. The long bones, which showed bowing, could be bent like sole leather and cut easily with a knife. The cystic areas contained a soft, brown material. The periosteum was very thick. The calvarium which was 0.5 inch thick, cut easily. The left parathyroid contained a tumor. The bony swellings were typical giant-cell tumors.

While this patient died from an intercurrent intestinal obstruction, her miserable general condition, due to parathyroidism, prevented proper attention to her fatal complication. This case was not diagnosed—she died before the condition was generally known.

Case 2. (Fatal, not operated upon). Mrs. L. A. M., age 45 years, had an extreme kyphosis of her softened spinal column, causing interference with the vital capacity of her lungs, described above. She had multiple fractures and many softened areas in the long bones and skull. Dr. R. C. Moehlig diagnosed the case properly, but, as operation at that time did not promise much, it was declined by the patient. The determination of her serum calcium and phosphorus and the roentgenographic films readily confirmed the diagnosis.

Case 3. Mr. H. J., age 65 years. The onset of symptoms was in 1926, when the patient complained of severe backache, leg ache, and curvature of the spine. His height diminished two inches. X-ray examination showed a destructive process and compression of the lower dorsal and upper lumbar vertebræ. A diagnosis of

metastatic malignancy was made, later, multiple myeloma was suggested. Still later, tuberculosis or syphilis of the spine was also considered. The man was entirely disabled and morphine had to be given freely. Later roentgenograms showed involvement of the second ribs, right femur, and compression of the intervertebral discs. Blood calcium in 1929, 11.4, in 1930, 14.8. Urine sugar, 4+, casts and albumin, 2+. There was evidence of metastatic calcification in the aorta. Dr R. C. Moehlig made the correct diagnosis.

A parathyroidectomy was performed, an adenomatous parathyroid being removed. The result was splendid. The man came back from his previous invalidism to a fairly happy life. He discontinued his morphine, and was able to walk and travel again for 18 months, when a sudden uremic attack led to death.

Although, strictly speaking, this case should not be termed a post-operative fatality, death was due to nephritis caused by the hypercalcemia existing before the operation. The case is mentioned as a fatality to stress the fact that parathyroidism leads to nephritis by means of metastatic lime deposits in the kidney. Bulger, Barr, Dixon, and Schregardus also mentioned a case of parathyroidism in which the patient died from pyelitis 18 months after parathyroidectomy. He had had dysuria and skeletal symptoms 20 years before the operation.

Fatal cases from lime deposits in the gastric and intestinal mucosa, leading to uncontrollable vomiting, dehydration, etc., have been mentioned in the literature (Charles Gibson's case vomited constantly for five weeks before the operation and died 18 hours after parathyroidectomy from the previously existing dehydration). Almost identical cases have also been described by Ask-Upmark, R. M. Wilder, and others.

So far real parathyroidism has not been cured by medical means in spite of attempts by prominent internists (among them, Donald Hunter, Snapper, Wilder)

If amelioration takes place, it is because either the relief is only of short duration, which is not unusual in endocrine disorders, or the symptoms are due to temporary disturbance from malnutrition (avitaminosis or a nutritional osteomalacia), which has been mistaken for real parathyroidism. Because the operative results, and perhaps also a few results from radiation, are quite striking, medical treatment should not be continued too long as serious deformities, renal lesions, etc., would prevent total recovery.

#### VERTEBRAL TYPE

Case 4 R. C., male, age 55 years. In January, 1930, the onset of the symptoms took place, consisting of backache and sacro-iliac distress. A diagnosis of sacro-iliac and vertebral hypertrophic osteoarthritis was made. However, the condition progressed and in May, 1930, there was a wedge-shaped fracture of the second dorsal vertebra, with general demineralization and marked pain. The height decreased 2.5 inches. The diagnosis of myeloma or metastatic malignancy was suggested. The man was disabled and required corset and crutches. The blood calcium varied from 11.3 to 18.6.

On Sept. 13, 1930 a bilateral thyroid lobectomy has performed and two parathyroids removed. Microscopy showed hyperplasia of the parathyroid tissue. The post-operative blood calcium varied from 13 to 10 mg, but it is now normal (August, 1932). There was a marked improvement in the lime content.

The patient has returned to work (May, 1931), gained 20 pounds, and still remains clinically cured, 26 months after the operation.

Case 5 Mrs. M. R., age 47 years. The onset of symptoms was in 1921, when the patient commenced to have backaches. In 1914 hysterectomy was performed. In 1929, the woman had a fall, resulting in what was considered a compression fracture of the eighth dorsal vertebra. A corset was used, giving temporary relief,

but soon she again complained of severe girdle pain, which was now more extensive

Roentgenographic check-up of her skeleton showed a granular appearance of the skull, demineralization of all the bones, and compressions of the third, seventh, eighth, ninth, and tenth dorsal and the lumbar vertebrae. There was herniation of the nucleus pulposus in the mid-dorsal, lower dorsal, and all the lumbar segments. The blood calcium at different readings was 10.9, 12, 11, 9, 14, and 10.9. Operation was performed on Oct. 13, 1931, when an adenomatous goiter and two parathyroids were removed. The latter were transplanted in a tetany case with good results (physiologic test). There was immediate relief from pain and the patient was able to walk when she left the hospital. On Jan. 18, 1932, the woman was seen. She had gained much weight and was practically free of pain. The kyphosis has straightened out remarkably.

Case 6 F. O., age 40 years, reported during August, 1931, complaining of pain in the small of the back and both hips, weakness of legs and back and of tiring easily. The onset was sudden, while the man was playing ball. A frame and brace were applied.

*Physical Examination*—Sept. 11, 1932. Kyphosis, tenderness of lumbar muscles, and rigidity of the back.

*X-ray Examination*—Demineralization of ribs. Compression fracture of the eleventh dorsal vertebra and herniation of the nucleus pulposus. Irregular granular type of rarefaction of the skull, pelvis, and femora.

On March 5, 1932, subtotal thyroid lobectomy was done, with removal of the inferior parathyroid. The microscopic report was adenoma of the thyroid and hyperplastic parathyroid. Post-operative blood calcium, 8.6, 9, 4.11.

An Albee spinal graft was recommended to support the broken vertebra, as a corset gave the man no relief from pain. A general survey of the skeleton showed osteitis fibrosa cystica, which had pro-

gressed to the skull, and other areas of rarefaction. Since the parathyroidectomy, the patient has been able to work for five months and now, eight months after the operation, he has continued to be improved.

From these vertebral cases (Cases 3, 4, 5, and 6) the lesson should be drawn that, in vertebral compression of uncertain origin, general skeletal x-ray examinations, calcium studies, etc., are indicated. These may lead to the proper diagnosis of parathyroidism and at times prevent unnecessary operation. If the vertebral type is properly diagnosed in mid-life, good results are attained from removal of the offending parathyroid. It is the most frequent type seen at this age.

#### TYPES OF PARATHYROIDISM WITH BONE CYSTS, GIANT-CELL TUMORS, AND FRACTURES

Case 7 Mrs. M. M., colored, 30 years of age. The symptoms were first noted at 15 years of age, when there was a pathologic fracture of the left femur below the hip. A cast was applied and the patient was in bed for about eight weeks. In 1926, after myomectomy, the leg became painful, and pain developed in the left elbow. The woman had to use crutches and was confined to bed most of the time. X-ray examination revealed a cyst-like process with a pathologic fracture of the left femur, a smaller area of cystic changes in both iliac bones near the sacro-iliac synchondroses, and an avulsion fracture of the left elbow. The blood calcium was 11. The diagnosis was parathyroidism.

Operation was performed in February, 1931, a bilateral subtotal thyroid lobectomy being done, with removal of two inferior parathyroids. Microscopy showed adenomatous changes with large fat islands.

The post-operative course was good, with final recovery and the woman now walks without a cane. Roentgenograms reveal that the cysts have become smaller, and there is a slight increase in lime content.

Case 8 E. P., female, age 14 years, was operated on by Dr. G. Penberthy, after

consultation with one of us (M B) The child had been bed-ridden for a long time and decubital scars gave testimony of how profoundly sick she had been Because of her age, the coxa vara, and numerous fractures, etc., she evidently belongs also to the infantile type, which we will describe later But we have inserted her case on account of the giant-cell tumors, cysts, and fractures around her elbow which all practically disappeared after removal of an adenomatous parathyroid The improvement could be seen by a comparison of the first and second films, which were taken before and after the operation

In mentioning cyst formation in parathyroidism, it should also be stated that giant-cell tumors (18) and cysts of the jaw may be due to this disturbance They have been cured by removal of hyperplastic or tumorous parathyroids, even though repeated curettements of the cysts have failed (Barr and Bulger, and Hunter)

#### INFANTILE TYPE

Many cases of parathyroid disturbances start early in life One of us (M B) now has under observation a fully developed case in a girl 18 months old The lesions, which are typical of the entity under discussion, are entirely different from rickets A few cases show that first disturbances have taken place near the hip joint and neck of the femur, where weight-bearing obviously caused early deformity Coxa vara, slipping epiphyses, "chondroma-like" formation, and cysts are often the diagnoses At times, one leg is more affected than the other A single bony involvement will hide at first a general affection ("arrested type of parathyroidism," Shallow) Our Cases 7 and 8 started as of the infantile type

Case 9 B N, a girl 5 years old, was first seen in 1927, at a time when little was known about parathyroidism The outstanding symptoms then were shortening of the left leg, coxa vara, and fractures of the left femur and tibia Biopsy of a bony swelling around the

greater trochanter resulted in the report of chondroma Orthopedic treatment, light, and dietetic measures did not stop the progress More fractures of the tibia followed, the last one in 1931 After becoming familiar with parathyroidism, a further check-up showed that there was general roentgen evidence of osteitis fibrosa cystica, elevated blood calcium, and so on

On March 31, 1932, two lower parathyroids were removed The patient improved rapidly, and grew two inches in seven months following the operation Recalcification of the whole skeleton was evident in roentgenograms, so that in September, six months after the parathyroidectomy, an osteotomy of the deformed femur could be done There was good callus formation at the place of osteotomy, a process which had not occurred before in three previous fractures The whole skeleton shows roentgenologic evidence of recalcification

Case 10 Exactly the same sequence of events, the same coxa vara, and same recalcification occurred in another little girl, age 6 years, before and after removal of a compact hyperplastic parathyroid tumor We have seen these peculiarities five times now in infantile types

#### ARTHRITIC TYPES

Oppel brought forth the suggestion that multiple ankylosing arthritis may be of parathyroid origin, basing his observations on 70 parathyroidectomies he had performed for such arthritis His reasoning for this is as follows An infectious arthritis usually does not lead to ankylosis, but, if there is a hypercalcemia, deposits of calcium will take place around the infected articular and peri-articular tissues Therefore, if such ankylosing polyarthritis shows parathyroid symptoms, a moderate increase of the serum calcium, hypotonia of the muscles, or other skeletal changes of decalcification, a parathyroidectomy is indicated A warning here is in order Parathyroidectomy is not a cure for

arthritis, but parathyroidism may accompany arthritic symptoms which may be the outstanding characteristic. Proper selection of such cases will prevent disappointment. In 41 cases of ankylosing polyarthritis, Oppel found the serum calcium at the upper limits of normal. His results from operation demand attention. Of 31 patients observed post-operatively for from seven months to two years, 16 were improved. This percentage is high, when we consider that Oppel always performed only a unilateral parathyroidectomy and that, in 11 cases, no parathyroid tissue was found.

A few cases of our own experience are as follows.

Case 11. Mr. A. H., 38 years old. The onset of his symptoms was in 1923, consisting of interphalangeal arthritis and arthritis of the left knee, accompanied by nervousness. X-ray examination revealed hypertrophic osteo-arthritis of the interphalangeal joints, knee joints, and spine. There was also decalcification of the spine. The blood calcium was 10 and the chronaxia was high. At operation on Sept. 14, 1931, an adenomatous thyroid and a parathyroid tumor, 1.5 cm. in diameter, were removed. Microscopy showed an island of parathyroid with new forming acini and fat, and cystic degeneration. Post-operatively the condition was markedly improved, and the joints became smaller. The blood calcium was 11.4, 9, 8.4. Improvement has now lasted for 14 months.

Case 12. Mrs. McA., 26 years old. In 1929, following pregnancy, the disease had its onset, with backaches and stiffness and a high dorsal kyphosis which resisted good orthopedic care. The joints were severely painful, so that insomnia resulted.

*X-ray Examination*—Marked dorsal kyphosis with diminished intervertebral space, so that the anterior processes of the segments approached each other. The bodies of the sixth, seventh, and eighth vertebrae were narrowed.

The blood calcium was 10.4 and 11.5. There was evidence of pyelitis, with dysuria

at times. On May 18, 1931, bilateral thyroid lobectomy was performed and two inferior parathyroids were removed. As a biologic test the parathyroids were transplanted to a case of tetany, with relief of tetany symptoms. The post-operative course was smooth, and there was immediate relief from pain, for the first time in two years. The improvement has continued for 18 months.

#### PAGET'S DISEASE

The identity of Paget's disease of the bone and osteitis fibrosa cystica (von Recklinghausen) has always been a point of dispute. Those who believe that they are two separate diseases cite differences in the microscopic structure and in the gross appearance of the bones, also the fact that Paget's disease in from 15 to 17 per cent of cases is followed by sarcoma. However, none of these differentiations is constant. They can be explained by the fact that Paget's disease occurs practically only after mid-life, and is a slower, more chronic form of parathyroidism. This also tells us why the changes in calcium metabolism, and so forth, are not so pronounced. We should bring the two under one heading because

1. Quite a few cases have now been observed in which, in the same individual, some bones show the characteristics of Paget's disease and others of osteitis fibrosa cystica (5, 14).

2. Both types of symptoms improve after parathyroidectomy.

From our own observations we mention two cases of clear Paget's disease, improved by parathyroidectomy. If we are correct, there is certainly another marked therapeutic reason for classifying the two diseases as one.

Case 13, which showed marked thickening of the skull, fuzzy and ill-defined outline (resembling a negro's wool), and typical Paget's changes of the femur, showed marked general clinical improvement after operation and there was roentgen evidence of improvement in the bones

of the skull and legs. There was return of the muscular strength, with relief of pain.

Case 13 F T, 53 years old. The onset of symptoms was from five to ten years before the present examination. The hat size increased from 7½ to 8½. Since 1918 there had been a loss of five inches in height. Other complaints were deafness, pain in the hand and the hips, and reduction of physical strength. The blood calcium was 11. X-ray examination showed typical changes of Paget's disease. On Nov 11, 1931, parathyroidectomy was done. Microscopically the parathyroid was richly vascular. There was a smooth recovery with marked physical improvement and disappearance of pain.

Case 14 Mrs S U, 63 years old. This was a typical case of Paget's disease, with gross bony changes in the left femur. More or less deviation was noted on general roentgenographic check-up. The left femur was bowed, shortened, and painful, with roentgen evidence of Paget's disease. The blood calcium was 11.6 and 12.7. Thyro-parathyroidectomy, done on March 22, 1932, revealed an adenomatous thyroid and a parathyroid tumor. Biopsy was confirmatory of typical Paget's disease. Microscopically the parathyroid was compact and adenomatous.

The patient gained weight, and the pain disappeared. Roentgenographic check-up showed marked evidence of return of normal bone structure.

#### CONCLUSIONS

1. The true type of parathyroidism will not yield to medical care and should, therefore, be operated upon early to avoid crippling, or even a fatal outcome.

2. In the recognition of parathyroidism, the roentgenologist is, perhaps, the most important factor. Only in a very few exceptional cases will the roentgenogram be negative.

3. In cases of compression fracture of the spine, which cannot be explained by severe trauma or metastatic malignancy,

a check-up of the whole skeleton, especially the skull and spine, will often lead to the diagnosis of parathyroidism. If the x-ray investigation is limited to the part complained of, the disease may be overlooked.

4. Parathyroidism is so frequent that it should be kept much more in mind than it has been heretofore. In doubtful cases, a general check-up of the skeleton by x-ray examinations, and also chemical tests for calcium and phosphorus and determination of the hypotonic condition of the muscles, will lead to more frequent recognition of the entity.

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## THE PTOSED GALL BLADDER, A ROENTGENOLOGICAL STUDY<sup>1</sup>

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THE cholecystographic study in the routine roentgen visualization of the gall bladder is now recognized as a highly important and efficient method in the diagnosis of diseases of this organ. This procedure, in addition to contributing considerable information as to the pathologic changes, likewise lends itself admirably for physiologic and anatomic investigation. Previous to the period of the discovery of cholecystography there were no direct methods, aside from surgical, that could be satisfactorily utilized in studying the physiologic and anatomic variations of the vesicle. Since then, however, considerable impetus has been given to this subject and attention frequently has been directed to the signal importance of this procedure in the study of gall-bladder affections. It has been demonstrated, likewise, that the anatomical aspects can also be better determined by this method, inasmuch as it well presents in the living subject the exact position, size, shape, mobility, and contractility of the gall bladder as well as its relation to the adjacent organs.

Considerable literature has accumulated since this test was established, most of which relates to the diagnostic procedures. Recently, however, much information has been obtained regarding the physiology of the gall bladder as a result of this method of investigation. However, the cholecystographic anatomical research of this organ has been more or less neglected, and up to this time there has been but scant consideration given the subject, particularly from this standpoint. A large portion of the literature deals with the diagnostic reliability of the unfilled gall bladder, while the filled vesicle, being more

difficult to evaluate, has not as yet been studied with the same degree of precision for possible evidence of early disease. The filled gall bladder, even though it may give a normal roentgenologic response to this test, may nevertheless in many instances harbor early pathologic changes. It has been shown that at least 15 per cent of the normally filled gall bladders reveal cholecystic infections. It is of interest, therefore, to study the filled gall bladder with meticulous care in order to further the diagnostic possibilities of this procedure.

In this study we especially desire to consider some of the roentgenologic anatomic aspects of the filled gall bladder. An attempt will be made to demonstrate some of its normal and abnormal phases and the relationship of the position of the gall bladder to the stomach and colon. For this study a group of 105 cases was investigated. The examinations were made sixteen hours after the gall bladder had been filled, following the oral administration of tetraiodophenolphthalein. The following findings were then considered: (1) Relation of the position of the gall bladder to the lower margin of the liver, (2) position, measured from a fixed point, (3) size, (4) shape, (5) contractility, and (6) relation to the position of the stomach and colon.

*Position of the Gall Bladder with Relation to the Lower Margin of the Liver*—This was observed to be of paramount importance. Four distinct types were noted, as illustrated in Figure 1. In Type 1, the transverse gall bladder was found lying above the lower margin of the liver. Type 2 presents the vertical gall bladder with most of its shadow above the lower margin of the liver. Type 3 represents that form in which the gall bladder hangs below the liver, being either in the vertical or oblique

<sup>1</sup> Presented before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1, 1932.



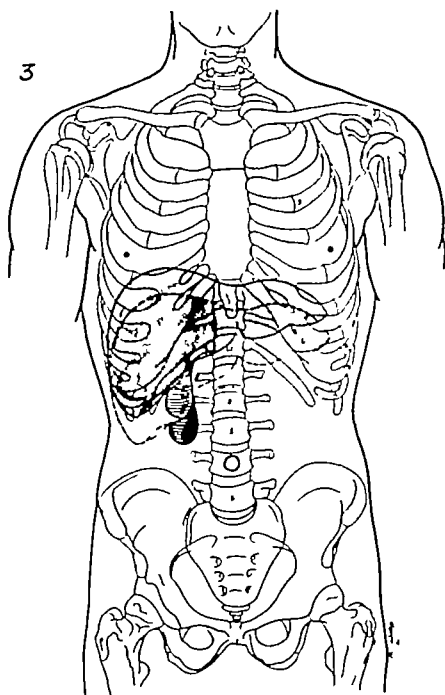
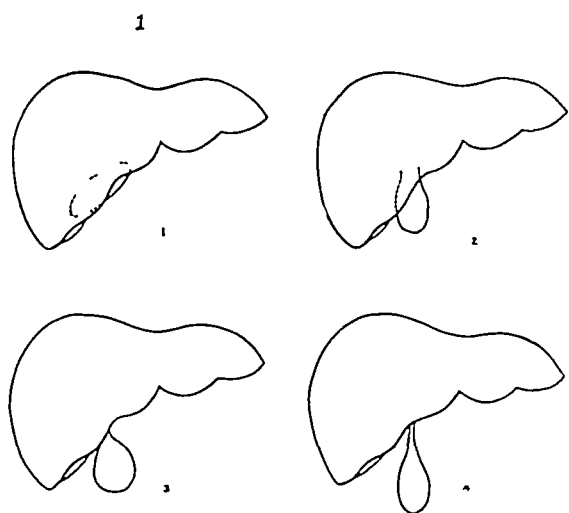


Fig 1 Illustrates the four types of gall bladders according to relation to the lower margin of the liver

Fig 2 Shows the gall bladder in normal position and its relative position to the vertebræ

position Type 4 represents the pendulous gall bladder, usually of the vertical type and presenting itself below the liver margin

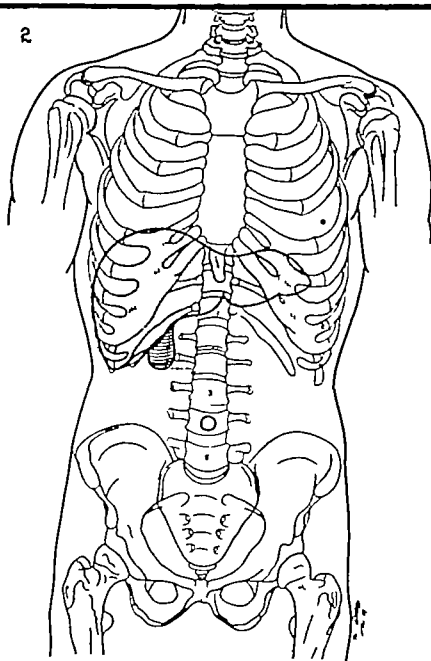
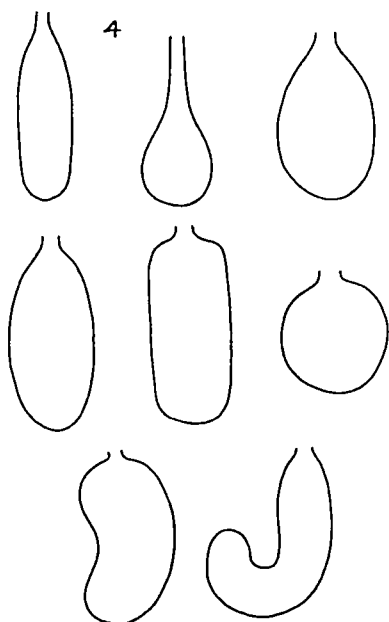


Fig 3 Illustrates the mobility of the gall bladder, between the inspiratory and expiratory phases of respiration

Fig 4 Diagrammatic drawing of the various shapes of gall bladders

In this series of 105 cases, the following types were observed Type 1, 11 cases, Type 2, 39 cases, Type 3, 42 cases, Type 4, 13 cases It thus becomes evident

from this study that in the majority, Types 2 and 3 predominate, together, these groups comprise 81 of the cases, while in Types 1 and 4 there were but 24

*Position*—The position of the gall bladder varies considerably in different individuals and may likewise vary in the same individual at different examinations. Little attention has hitherto been directed to the position of the gall bladder, though in my opinion this may be of importance and may in some instances be responsible for the production of symptoms referable to the organ—this is especially true as to the ptosed gall bladder. The position of the vesicle in this series was measured from an anatomical landmark, using the vertebra as a fixed point. The measurements were made from the tip of the fundus to the level of the transverse process of the vertebra. (See Fig 2)

In the 105 cases the following positions were encountered. Six were found to be on the level of the twelfth dorsal vertebra, 14 on the level of the first lumbar, 28 on the level of the second lumbar, 41 on the level of the third lumbar, 10 on the level of the fourth lumbar, and 6 on the level of the fifth lumbar vertebra. The examinations were made in the prone position and measured during the inspiratory phase of respiration. As a rule, the gall bladder occupies a position between the second and third lumbar vertebrae, it is possible, however, to find it in the pelvis. The location of the gall bladder should always be noted in the roentgenographic records, inasmuch as this finding may occasionally have some bearing upon the diagnosis, for the possibility of a ptosed gall bladder being responsible in some instances for the production of intermittent attacks of right upper quadrant symptoms should always be borne in mind. It is quite significant that in a not inconsiderable number of instances a ptosed vesicle may be the only objective sign pointing directly to a possible gall-bladder disturbance. On the other hand, it is by no means safe to state that the ptosed gall

bladder is always pathologic, unless other abnormal signs co-exist.

Between attacks the ptosed gall bladder may fill well and function normally. On the contrary, notwithstanding this finding, it may show a distinct abnormal roentgenologic response during an attack. Such gall bladders, however, are most commonly diagnosed as normal, since examinations are usually performed in the interval between attacks. It is highly probable, however, that, under certain conditions, when the gall bladder is filled and distended, a dragging of the ptosed vesicle may produce a pressure or kink in the duct, which may in some instances even give rise to jaundice. It is quite possible too, under certain circumstances, for a markedly ptosed vesicle to become twisted, thereby producing a torsion of the cystic duct or of the gall bladder itself. This abnormal position must be considered, therefore, as a potential source of disturbance.

In the recurrent attacks in which abnormal pressure is made on the duct or when kinking occurs, a stagnation within the gall bladder may be produced which may favor the production of infection and consequently the formation of stones. In the persistently ptosed gall bladder in which the above changes have occurred over a long period of time, the vesicle may become dilated and more or less atonic. At this stage functional changes may occur. It is of interest to add that when the ptosed gall bladder functions well, the density of the shadow may even be greater than is usually observed in the normal vesicle.

In the atonic condition, the density of the gall-bladder shadow is frequently diminished. There is also a lessened degree of absorption and the filling is somewhat retarded. The emptying time is often slowed and in some instances may be markedly checked, so that little contraction occurs following a fatty meal. These changes occur as a result of a loss of tone or atrophy of the wall of the vesicle.

Of our 105 cases, 74 were found to be

normal from a cholecystographic standpoint and 31 abnormal. Of the 31 abnormal cases, 14 revealed evidences of cholecystitis without stones, 13 revealed stones, and in 4 pericholecystic adhesions were noted.

The positions of the normal gall bladders were compared with those of the abnormals and it was found that no definite relationship could be shown to exist as to the position of the gall bladder and the production of cholecystitis or stones.

In this series there were 16 presenting a low type of gall bladder, occupying a level between the fourth and fifth lumbar vertebræ. Of these, 13 may be classified in the group recognized as Type 4. These gall bladders hang low and are of the pendulous type. It is worthy of note that of the 16 cases in which the vesicle was situated low, there were only 4 (25 per cent) which presented definite pathologic cholecystographic changes.

While these findings are not entirely conclusive, they tend to indicate that the low type of gall bladder is not necessarily more prone to become diseased. Of the entire group, but slightly more than 30 per cent revealed pathologic gall-bladder changes. This series is without doubt rather small upon which to base definite conclusions, but it does clearly indicate that in general the position of the gall bladder bears but little definite relationship to the presence of disease of this organ. It must be remembered, however, that it does not appear justifiable to arrive at conclusions from the roentgenologic studies alone. Even in instances in which the gall bladder responds normally to the cholecystographic test, abnormal changes may be present. The rôle played by the ptosed gall bladder may be of importance, however, in some instances as bearing a direct etiologic relationship to the production of disease of this organ.

*Stagnation and Stasis within the Gall Bladder*—Stagnation of bile in the vesicle may favor the production of infection or stones. A ptosed gall bladder may at times be responsible for stagnation, result-

ing in these changes, yet it is quite true that in the majority of instances no evidence of stagnation is encountered in this type of gall bladder. Stagnation resulting in poor emptying of the vesicle occurred in only three instances of the 16 low type gall bladders in the writer's series. These cases were examined during the period of quiescence, which may account for the small number with stasis. On the other hand, a ptosed vesicle may present definite evidence of stagnation, according to my observation, when the examination is made during an attack. It must be pointed out, however, that in some instances it may not be possible to visualize the vesicle during a gall-bladder attack, due to the transient obstruction of the cystic duct.

*The Latent Gall Bladder*—As a result of ptosis of the vesicle a low grade infection may be produced, with few if any symptoms referable to this organ. The cholecystograms in this type may reveal findings within normal limits and no clue may be obtained to incriminate the gall bladder as a possible source of infection. This latent type occurs not infrequently and may account for certain cases of cholecystitis recognized at operation, notwithstanding the fact that from a roentgenological viewpoint they were considered normal.

*Mobility of the Gall Bladder*—The mobility of the gall bladder is another interesting phase, revealing as it does the vesicle on different levels. This is of importance inasmuch as it is always desirable, when possible, to observe the shifting of the gall-bladder shadow, in order to separate it from that of the colon and also to note whether or not a suspected stone shadow or tumor defect changes its position with the vesicle. At times the shifting produces a more distinct and sharply defined shadow. It is well recognized that the liver and gall bladder move during respiration with the ascent and descent of the diaphragm. The position of the gall bladder was at first recorded with measurements made in inspiration and then again in expiration. (See Fig. 3.)

In this series of cases the following findings were observed as to the mobility of the gall bladder. In 11 instances this organ remained immobile, in the remaining the differences in the shifting varied from one-half of an inch to three inches. No relationship could be determined between the mobility of the normal and pathologic gall bladders.

*Size of the Gall Bladder*—The size of the gall bladder visualized 16 hours after the oral administration of the dye varies considerably in the cholecystograms. The measurements were obtained during the inspiratory phase of respiration at a distance of 25 inches on the Bucky diaphragm. In the entire series the size ranged between 15 and 55 mm. in the 74 normal cases the size varied between 23 and 45 mm., with an average of 32 mm., in the pathologic cases, from 25 to 45 mm. in the gall-stone cases, with an average of 34 mm., while in the cases of cholecystitis it ranged from 15 to 55 mm., averaging 37 millimeters.

The size of the gall bladder usually varies between the two phases of respiration. During expiration it was observed that normally its size was usually diminished and in many instances this variation in size was very marked.

*Shape*—The shape of the gall-bladder shadow in this series presented no significant variation between the normal and abnormal, except in a few instances in which the gall bladder was found to be deformed and distorted as a result of adhesions or disease. The shape varies at times, depending upon the respiratory phase. The various shapes encountered in this series were as follows: tubular, oval, pendulum-like, banana-like, pill-like, circular, kidney-shaped, and hooked (Fig. 4).

*Contractility of the Gall Bladder*—Following a fatty meal the gall bladder showed a normal contraction in 73 cases, poor contraction in 15, and no contraction in but 2. It emptied in 15 cases. These findings indicate that when the gall bladder actually fills, about 70 per cent of the cases contract normally.

*Relation of the Position of the Gall Bladder to That of the Stomach and Colon*—In the study of the ptosed gall bladder it was of interest to demonstrate its relation to the adjacent organs. The low position of the gall bladder is usually associated with a ptosis of the stomach and colon. In the group of 105 cases, a gastro-intestinal examination was made in 70. Table I illustrates the comparative relation of the position of the gall bladder, stomach, and colon.

This comparative examination disclosed the fact that a definite relationship exists between the position of the gall bladder and that of the stomach and colon. As a rule, it may be stated that the higher the position of the gall bladder, the more apt is one to find the stomach and colon likewise high. On the contrary, when the gall bladder occupies a low position, a similar finding is usually observed with regard to the stomach or colon or both.

#### SUMMARY

A study of 105 consecutively filled gall bladders was made to determine the position of the organ, with special reference to the ptosed gall bladder and its significance.

In most clinics, the routine roentgen examination is usually made in the prone position and hence all the gall bladders in this series were measured from films made in the recumbent posture. However, we have fluoroscoped many of these, but no record was then made of the position. We<sup>2</sup> have stressed the importance of the fluoroscopic visualization of the gall bladder in the upright posture as an important procedure in the routine investigation of this organ. In order to further study its position, it would be well to further investigate the gall bladder in the upright posture, for it is quite evident that the reported number of low type gall bladders would greatly increase if this technique were routinely utilized.

In a consideration of the ptosed gall

<sup>2</sup> Theodore H. Morrison and Maurice Feldman. *Ann Clin. Med.*, October, 1926, IV, 330.

normal from a cholecystographic standpoint and 31 abnormal. Of the 31 abnormal cases, 14 revealed evidences of cholecystitis without stones, 13 revealed stones, and in 4 pericholecystic adhesions were noted.

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bladder occupies a low position. The time of filling and emptying, as determined by cholecystography, is practically the same, regardless of the position of the gall bladder. If ptosis were conducive to stasis of bile, resulting in subsequent infection and stone formation, we would expect to find stones more frequently, whereas cholelithiasis is actually relatively

uncommon in patients of this habitus

Dr. Feldman called attention to the possibility of jaundice resulting from kinking of the ducts, due to ptosis. That is an interesting observation and certainly should be given our consideration in cases of undetermined jaundice occurring in ptotics.

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TABLE I

No cases	Position of gall bladder	Position of stomach	Position of colon
2	12th dorsal vertebra	normal	normal
9	1st lumbar	normal	normal
19	2nd lumbar	16 normal 2 slightly ptosed 1 moderately ptosed	12 normal 3 moderately ptosed 4 markedly ptosed
28	3rd lumbar	20 normal 6 slightly ptosed 2 moderately ptosed	19 normal 2 slightly ptosed 6 moderately ptosed 1 markedly ptosed
7	4th lumbar	4 normal 2 slightly ptosed 1 maximum ptosed	2 normal 2 slightly ptosed 1 moderately ptosed 2 maximum ptosed
5	5th lumbar	0 normal 2 slightly ptosed 1 moderately ptosed 2 markedly ptosed	0 normal 3 moderately ptosed 1 markedly ptosed 1 maximum ptosed

bladder it is of interest to study the habitus of the patient, for it is well known that in viscerotonic individuals, all the gastro-intestinal organs are situated low and consequently a low position of the gall bladder may more commonly be found in this type

One other point deserves mention, namely, the position of the liver. In not a single instance was the liver found to be ptosed. When the gall bladder hung low, with the other digestive organs, the liver remained in its normal position.

#### CONCLUSIONS

1 The ptosed gall bladder should be considered whenever a cholecystographic study is undertaken.

2 It is quite probable that this condition may be a factor, in some instances favoring the development of infection or stones.

3 There appears to be a definite relationship between the positions of the gall bladder and that of the stomach and colon.

4 The position of the gall bladder should always be recorded in the cholecystographic report.

5 The majority of gall bladders are found to be normally located on a level

of between the second and third lumbar vertebrae.

6 In a study of gall bladders presenting lesions of various kinds, no relationship can be determined as to the diseased condition and that of the position or mobility of this organ.

7 The size of the gall bladder changes with respiration. It is found to be larger in inspiration and smaller in expiration.

8 The majority of filled gall bladders of the ptosed type will contract well, despite the fact that there may be a low-grade infection present.

9 Finally, the actual significance of this condition can be arrived at, by a more intensive study, correlating it with the associated clinical manifestations.

#### DISCUSSION

DR LESTER LEVYN (Buffalo) Dr Feldman is to be congratulated upon this excellent consideration of the ptosed gall bladder. The low gall bladder is encountered frequently and usually accompanies ptosis of the other viscera common to individuals of the hyposthenic habitus. I have not observed that disturbance of function occurs merely because the gall

bladder occupies a low position. The time of filling and emptying, as determined by cholecystography, is practically the same, regardless of the position of the gall bladder. If ptosis were conducive to stasis of bile, resulting in subsequent infection and stone formation, we would expect to find stones more frequently, whereas cholelithiasis is actually relatively

uncommon in patients of this habitus

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# ROENTGENOLOGIC OBSERVATIONS OF THE COLON IN AMEBIC DYSENTERY

WITH REPORT OF SEVEN CASES ORIGINATING IN CHICAGO<sup>1</sup>

By KANO IKEDA, M D, *St Paul*

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**A**N unusual opportunity was afforded the writer to record roentgenologic observations of the colon in amebic dysentery in a small series of patients who contracted the disease while visiting in Chicago during the Summer of 1933. A detailed account of nine of these cases has already been published elsewhere (1). The present communication will be confined to the discussion of the roentgenologic aspect of the changes found in the colon in seven patients, six from the same series, and one, a new case.

Unlike the cases reported in the literature, all of our cases furnished fairly accurate epidemiologic data and probably represented the uncomplicated stages of the disease with a lesion more or less localized and of comparatively short duration. Thus, it was possible to make an accurate correlation between the roentgen appearance of the specific lesion in the colon and the clinical stage of the disease.

The roentgenologic observation of the colon was undertaken both before and after the institution of emetine treatment in all but one of the seven cases. The examination was conducted primarily to elicit, if any, such changes in the colon as might be considered constant or characteristic in this disease during the particular stage of infection under our observation. At no time during the period of this study was the literature consulted. The observations, therefore, were original, independently made and recorded.

## LOCAL PATHOLOGY OF AMEBIC DYSENTERY

In order to better appreciate the roentgen appearance of the colon in amebic

dysentery, local pathologic anatomy may be briefly reviewed (2). It has been shown that the cysts of *Endameba histolytica* are carried down into the cecum before they become activated into the protozoan form. The normal alkaline reaction of the flora of the colon and the natural reservoir-like behavior of the cecum appear to favor the multiplication of the liberated amebas and the development of the first lesions in this portion of the colon. It is likely that the majority of the cases diagnosed and treated early may escape without further involvement than the cecum and the proximal portion of the ascending colon. The rectum, another dilated reservoir, is known to be the second common site of involvement, followed by the adjacent sigmoid. Clark (3), investigating the distribution of amebic lesions in 186 postmortem examinations, found the cecum to be involved in 88.7 per cent of the bodies, the ascending portion in 78 per cent, the rectum in 72.5 per cent, the sigmoid in 71.5 per cent, the splenic flexure in 63.4 per cent, the transverse portion in 61.2 per cent, the hepatic flexure in 60.7 per cent, and the appendix in 40.8 per cent. Of the 63 cases (33.8 per cent) which revealed the ulcers in certain regions only, 87.3 per cent were found in the cecum and 57.1 per cent in the ascending colon, 39.6 per cent in the rectum, 33.3 per cent in the sigmoid, 33.3 per cent in the appendix, 12.6 per cent in the splenic flexure, 6.3 per cent in the transverse colon, and 4.7 per cent each in the hepatic flexure and in the descending colon. The early lesions are essentially microscopic or quite superficial. The amebas penetrate the mucosa along the glandular slits and invade deeply into the submucosa, where they multiply and, by their cytolytic action, cause a rapid liquefaction necrosis

<sup>1</sup> Presented before the Minnesota Radiological Society, March 10, 1934. Submitted for publication

of the involved area. This is soon transformed into a cyst-like formation which becomes filled with glairy mucus and bulges out over the mucosal surface. At the point of primary invasion, a small superficial ulcer with a necrotic center develops. This communicates with the underlying submucosal area of necrosis. A well-developed lesion is characterized by a deep, irregular ulcer involving the submucosa and often penetrating into the circular bundles of the muscle layer, with an overhanging and undermining mucosal edge, a necrotic base, and an edema and induration of the surrounding tissues. There is also a tendency to establish submucosal inter-communications or tunnels between the ulcers. Two or more of these ulcers may thus become coalesced, leaving the overhanging bridges of a comparatively healthy mucosa which separate the primary ulcers. There are the usual inflammatory reactions of varying intensity involving the tissues all around the ulcers. Areas of repair and cicatrization and of fresh involvement are constantly added to the general pathologic picture. All these processes cause irregular induration and thickening of the wall and a consequent deformity and narrowing of the lumen. Doubtless, there develops functional disturbance in the muscular action of the wall, by reason of the unequal distribution of the lesions and of, what is probably more important, the changes in the biochemical reaction of the tissues, brought about by the metabolic products of the amebas, all of which add to the anatomic changes in the gut.

During the earlier stages of amebic dysentery, these lesions may be comparatively free of secondary infection, unless a co-existing bacillary dysentery complicates them from the beginning. In the presence of a secondary or co-existing infection, the gross appearance of the lesion may become more or less modified until, in extreme instances, the characteristic amebic ulcers of the colon may be entirely obscured.

Amebic lesions of long standing may develop into a granulomatous growth, in-

volving either a large segment of the colon diffusely or a single localized area, as a tumor (4). Two or more localized growths have also been observed, or both localized and diffuse lesions may co-exist in the same colon. A localized granulomatous lesion may cause an obstructive symptom and is easily mistaken for a cancerous growth, clinically and roentgenologically. In the diffuse type, the involvement is usually too extensive or the lesion too atypical in distribution and appearance to be either tuberculous or carcinomatous. Without the demonstration of *Endameba histolytica* in the stools or in the lesion, the condition may remain undiagnosed. Without the proper histologic examination, the anatomic lesions may resemble, grossly, cancer, tuberculosis, syphilis, or other granulomatous growths and may remain so diagnosed by the examiner.

The terminal ileum may become involved early. The ileocecal ring becomes stretched, due to the extension of the inflammation, and allows constant regurgitations of the fecal contents into the terminal ileum. This causes not only a mass migration of the amebas from the cecum into the ileum but also alkalinization of the fecal flora which favors their continued existence. The development of a primary amebic lesion in the small intestine is a disputed question. There seems to be no fundamental objection against believing that such a lesion may occur under certain unusual conditions.

#### REPORT OF CASES

The cases are divided into the acute, the sub-acute or recurrent acute, and the early chronic forms, depending upon the duration of illness in each instance. All of them were suffering from active dysentery and abdominal discomfort of varying intensity at the time of admission to the hospital. The diagnosis of amebic dysentery was readily established through the identification of *Endameba histolytica* in the stools.

Of the total of seven cases, two were in the acute stage, four in the sub-acute or

recurrent acute stage, and one in the early chronic stage. The clinical histories in these cases, with the exception of Case 3, will be found in detail in the published

made on the first day. Symptoms severe abdominal cramps as of an acute surgical condition.

*Roentgen examination of the colon on*



Fig 1-A (above) Case 2. The cecum and ascending colon immediately following evacuation of a barium enema on the seventh day of illness. Note the residue in the cecum. The appendix is long and its distal half irregularly dilated.

Fig 1-B (above) Case 2. The cecum and ascending colon about seventy-five days after the treatment began. Note a small filling defect along the medial aspect of the cecum near the base of the appendix, which is no longer dilated as in Figure 1-A.

Fig 2-A (below) Case 3. Shortening of the ascending colon and a slight irregularity and induration of the cecum.

Fig 2-B (below) Case 3. The same colon twelve days later, after a course of treatment.

article to which reference has already been made (1).

#### ACUTE FORM

Case 1, R. P., a school girl, aged 8, admission, Nov. 13, 1933, duration of present illness, a few hours, probable incubation period, 56 to 58 days. The diagnosis was

the second day of illness (Nov. 14), and again on March 24, 1934, was negative.

Case 2, E. H., female, aged 38, admission, Nov. 30, 1933, duration of the present illness at the time of admission, six days, probable incubation period, 74 to 77 days. The diagnosis was made on the sixth day of illness. Symptoms mild diarrhea, with fresh blood in stools, no other complaints.

*First roentgen examination* of the colon, on the seventh day of illness (Nov 31), was essentially negative except for slight spasm of the ascending colon and for a long appendix, showing a marked dilatation of its distal half, with an irregular filling of the lumen, suggesting a diffuse ulcerative lesion of the mucosa. No tenderness over the appendix or cecum (Fig 1-A).

*The second roentgen examination* (Feb 15), was made about 75 days after the beginning of treatment, while the patient was entirely symptom-free and the stools were repeatedly negative. There was no spasm in the colon, but a small area of filling defect along the medial aspect of the cecum over which there was definite tenderness. The roentgenograms (Fig 1-B) showed fine feathery or thorny irregularity along a coarse defect, probably representing a localized granulomatous thickening of the wall.

#### SUB-ACUTE OR RECURRENT ACUTE FORM

Case 3, C M, male, aged 67, admission, Jan 17, 1934, probable duration of the present illness, at the time of admission, 30 days, probable incubation period, about two months. The diagnosis was made on the thirtieth day of illness. Symptoms a period of obstipation followed by intermittent diarrhea and cramps, a violent attack of dysentery, with frequent explosive watery movements for two days before admission, vague tenderness over McBurney's point.

*First roentgen examination* of the colon on the thirty-first day of illness (Jan 18)—There was no spasm. The cecum and the ascending colon were shortened and "lifted-up" under the costal margin. There was localized rigidity of the wall, with irregularity of the outline at the distal end of the cecum (Fig 2-A). Definite tenderness over this area.

*Second roentgen examination* (Jan 30), twelve days after the institution of emetine treatment—The cecum and ascending colon were seen to be smooth and flexible in outline and had resumed the normal relative position (Fig 2-B).

Case 4, T P A, male, aged 52, admission, Oct 19, 1933, probable duration of the present illness, at the time of admission, 92 days, probable incubation period, 24-26 days. The diagnosis was made on the ninety-second day of illness. Symptoms. Recurrent attacks of abdominal discomfort and diarrhea and a "run-down" condition since the middle of July, together with an acute attack of diffuse abdominal tenderness and enlargement of the liver, with the temperature of 103° when admitted. No roentgen examination of the colon was possible at this time.

*First roentgen examination* of the colon on the day of discharge from the hospital (Nov 5), sixteen days after the beginning of treatment—The colon was diffusely dilated, the cecum showed a slight deformity but was not spastic or indurated, there was no local tenderness. The clinical improvement of the patient was slow.

The stools showed many cysts and occasional motile amebas at various times.

*Second roentgen examination*, March 5, 1934, four and a half months after the institution of the first emetine treatment—There was a slight deformity, with rigidity of the wall, along the medial aspect of the cecum which was quite tender on palpation. Deep spastic contractures developed, slowly involving the cecum and ascending colon (Figs 3-A and 3-B).

Case 5 H C, male, aged 51, admission, Oct 12, 1933, for a biopsy of a growth from the rectum which was negative for malignancy. Second admission, Oct 30, was for a second biopsy. The probable duration of the present illness, at the time of the second admission, was 75 days, the probable incubation period, 53-57 days. Symptoms. Recurrent attacks of abdominal cramps and diarrhea since Aug 15, 1933, marked rectal pain and tenesmus, for which a physician was consulted on Sept 10.

*First roentgen examination* of the colon, Sept 10, or about twenty-five days after the onset of illness, was reported negative (Fig 4-A).

The diagnosis of amebic dysentery was

not made until Nov 8, when the first specimen of stool was submitted for examination. Serial sections of the biopsied

eight days after the institution of treatment, while the stools still showed occasional cysts and motile amebas—There



Fig 3-A (above) Case 4 The colon about four and a half months after the patient's discharge from the hospital, showing an area of induration and a filling defect along the cecum, medially. There was definite tenderness over this area.

Fig 3-B (above) Case 4 The cecum and ascending colon a few minutes later showing deep spastic contractions.

Fig 4-A (below) Case 5 The colon twenty-five days after the onset of illness, reported negative. Note the slight contractural deformity of the cecum and ascending colon with loops of the terminal ileum prominently displaced along the ascending colon.

Fig 4-B (below) Case 5 The same colon ten days after the institution of the treatment and about two months after the first roentgenogram was taken. Note the saw-tooth irregularity in the transverse colon and the shaggy feathery defect of the rectum and sigmoid.

specimen from the rectum also showed nests of amebas.

Second roentgen examination, Nov 16,

was a slight deformity of the cecum and ascending colon, small areas of fine saw-tooth irregularity along the transverse

colon and coarse, feathery or shaggy filling defects along the rectum and sigmoid which were absent in the first roentgenograms (Sept 10) This indicated not only the development of fresh superficial ulcerative lesions in the transverse colon but the persistence of the granulomatous lesions of the rectum, in spite of the course of emetine treatment, just completed (Fig 4-B)

*Third roentgen examination*, Feb 6, three months after the institution of emetine treatment—For the first time, there was a high degree of spasticity in the cecum and ascending colon, in marked contrast to the behavior of the same area during the previous fluoroscopy There were, however, no demonstrable lesions either here or elsewhere in the colon, which had resumed its normal contour (Fig 7-A)

Case 6 C B, male, aged 59, admission, Oct 13, 1933, for a rectal biopsy, which was negative for malignancy, probable duration of the present illness, 45 days, probable incubation period, 7-15 days The diagnosis was made on the forty-fifth day of illness Symptoms Rectal pain and tenesmus, recurrent abdominal cramps and diarrhea, with blood, a boggy palpable mass, with tenderness on palpation, in the right lower quadrant

*First roentgen examination* of the colon (Oct 13), 44 days after the onset of illness—There was no demonstrable spasm of the colon There was an extensive filling defect involving the cecum and ascending colon, which appeared somewhat shortened and contracted There was palpable induration or infiltration in the wall, with an irregular narrowing of the lumen (Fig 5-4) There was retention of the barium in the lumen of the involved portion of the colon after the evacuation of the enema The shadow was interpreted as being due either to a chronic non-tuberculous inflammatory or granulomatous ulceration or an infiltrating growth such as leukemia or Hodgkin's disease Carcinoma was thought unlikely because of the extent of involvement and the apparent good health of the patient Tuberculosis

was not considered because of the absence of spasm Noted also was the patency of the ileocecal ring, indicating its involvement in the diffuse process The appearance of the terminal ileum suggested induration of the wall due to the extension of the lesion The stools had not been examined on this day and the patient was discharged

The second admission was on Oct 18, with a diagnosis of amebic dysentery A course of emetine treatment was given for ten days, after which there was a marked clinical improvement and rapid disappearance of the mass in the right lower quadrant

*Second roentgen examination*, Dec 11, about two months after the beginning of emetine treatment—The colon was reported to be normal The roentgenograms (Fig 5-B) showed the cecum and ascending colon to have resumed their normal length and diameter and their smooth outline and flexibility

#### EARLY CHRONIC FORM

Case 7 M M, female, aged 53, admission, Nov 21, 1933, probable duration of the present illness, at the time of admission, 125 days, probable incubation period, 9-14 days The diagnosis was made on the one hundred and twenty-fifth day of illness Symptoms Weakness, vague abdominal distress, and diarrhea, with a slight elevation of temperature (present since July, 1933), and periodic exacerbation of the symptoms

*First roentgen examination* of the colon (Nov 24), about one hundred and twenty-eight days after the onset of illness—There was an irregular narrowing of the lumen, with induration of the wall and obliteration of the haustral markings throughout the transverse colon and an identical deformity and shortening of the cecum and ascending colon, with fine irregularity of outline along the involved wall There was also a rigidity of the terminal ileum There was no spasm in the colon (Fig 6-4)

*Second roentgen examination*, Dec 8,

14 days after the institution of Stovarsol and emetine treatment—The colon was not spastic, its wall was soft and flexible, its outline smooth, and the haustration well defined. There was a small area of induration along the lateral aspect of the cecum which might represent a residual active lesion (Fig 6-B). A clinical improvement in the condition of the patient was equally remarkable during this period.

*Third roentgen examination* (March 10), about three and a half months after the beginning of treatment—The colon poorly tolerated the clyisma and showed a marked degree of spasticity, especially in the cecum and ascending parts. Small, spastic waves were also noted along the transverse colon. There were no demonstrable filling defects, but the behavior of the colon strongly suggested a re-activation of the old amebic colitis (Fig 7-B).

#### SUMMARY OF ROENTGEN FINDINGS

The roentgen appearance of the colon during the earlier stage of amebic dysentery was negative except for mild spasm. The duration of the incubation period had no bearing upon the roentgen findings. The patients (Cases 6 and 7) with the shortest incubation period (7–15 days and 9–14 days) showed the most marked involvement of the colon. An abnormal filling of the appendix was noted in Case 2, within a week of the onset, probably due to a primary amebic ulceration in this organ.

The fine, saw-tooth filling defects along the transverse colon in Case 5 might easily be due to early ulcerative lesions. The minute, shaggy irregularity of the outline along the rectum and sigmoid in the same case and the delicate feathery or thorny filling defects along the cecum in Case 2, in her later examination, probably represented a granulomatous, ulcerative lesion due to the infestation of *Endameba histolytica*.

During the sub-acute or early chronic stage of the disease, with active dysentery, the roentgen appearance of the colon was more definite. Fluoroscopically, the bar-

ium clyisma was tolerated without discomfort in every instance. No appreciable spasticity of the bowel was noted, a striking observation in view of the extent of the involvement. The involved area, usually the cecum and ascending colon, lacked the usual flexibility of the wall, which was now somewhat resistant and apparently indurated, under the palpating hands, as in Case 6. There was a shortening and upward displacement of the cecum, with demonstrable local deformity or filling defects. Local tenderness on palpation was not constant in every case. Spastic contractions and deformities were conspicuous by their absence.

By the extension of a like process into the transverse colon, the roentgen appearance of the colon in Case 7 became somewhat confusing with that of a chronic nonspecific ulcerative colitis. The latter, however, frequently involves the descending colon, which is seldom affected by amebic infection.

As a rule, varying amounts of barium residue were noted in the cecum after the evacuation of the enema, during the stage of active dysentery, indicating the absence of spasm in the involved portion. Frequently observed, also, was wide patency of the ileocecal ring, allowing constant flow of the clyisma into the terminal ileum, which was apparently invaded by the infection.

A difference in the roentgen appearance of the colon before the institution, and after the completion, of a course of emetine treatment, was strikingly demonstrated in several of the cases. The colon resumed its normal contour and position within as short a period as two weeks, as in Cases 3 and 7. The flexibility of the wall returned, the outline became smooth, the haustral markings were more distinct, while the filling defects and the general deformity of the involved area were no longer present.

A well-localized lesion in the cecum which apparently had developed during a symptom-free period of several months (in which medication had been continued

and the stools were free of motile amebas on repeated examinations) was unexpectedly demonstrated roentgenologically in Cases 2 and 4

The type of amebic lesion in the colon,

amples were found in Cases 6 and 7 In the former, a granuloma-like behavior of the lesion in the cecum and ascending colon was evident, while in the latter, though of a longer duration, a chronic

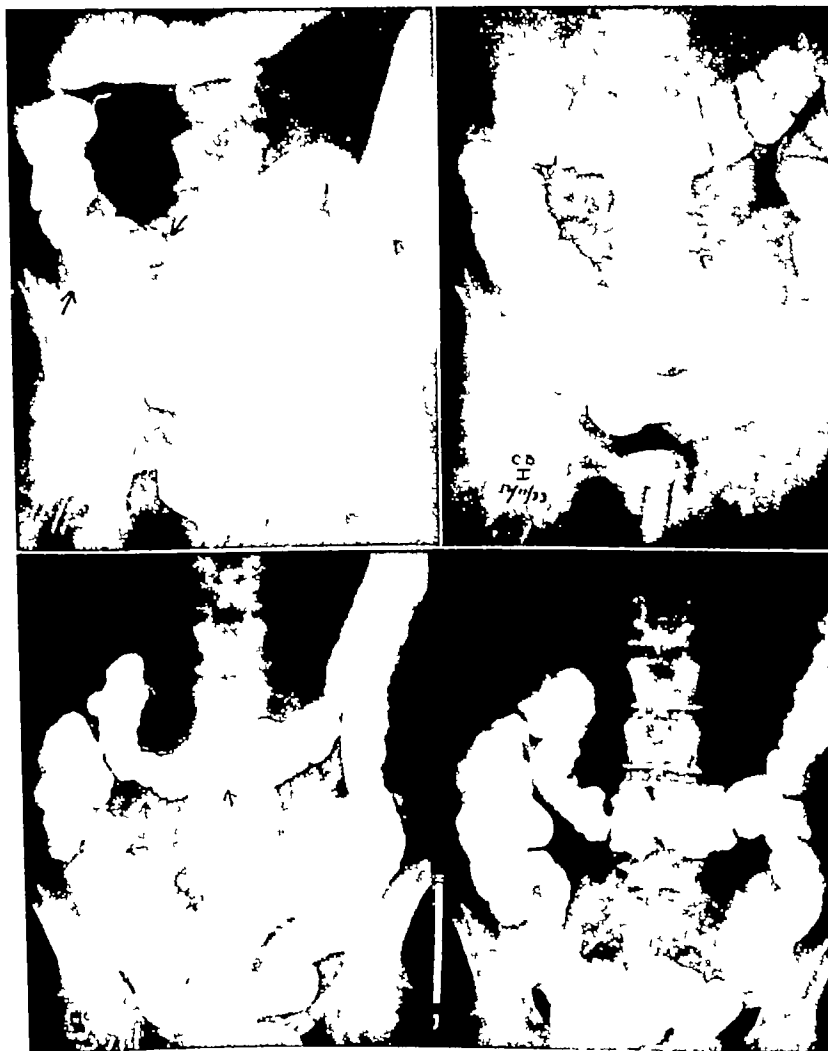


Fig 5-A (above) Case 6 Irregular narrowing and filling defect in the cecum and ascending colon on the forty-fourth day of illness Note the patent ileocecal opening and the filled terminal ileum

Fig 5-B (above) Case 6 The same colon, two months after the treatment was started Compare the appearance of the cecum and ascending colon with that in Figure 5-A

Fig 6-A (below) Case 7 A marked involvement of the cecum, ascending colon and transverse colon, on the one hundred and twenty-eighth day of illness Note the shortening and deformity of the ascending colon with a widely patent ileocecal valve and the dilated and apparently indurated terminal ileum

Fig 6-B (below) Case 7 The same colon after fourteen days of treatment Note the remarkable improvement in the appearance of the colon

revealed roentgenologically, may differ in individual cases The outstanding ex-

ulcerative feature was predominant A response to emetine therapy was equally



prompt and effective in either type of lesion

The absence of spasm in the involved portions of the colon and the apparent shortening or shrinking of the cecum and ascending colon during the active stage of the disease were the observations of importance which demand explanation. The demonstration, for the first time, of marked irritability and spasticity in the same areas, now apparently healed, in Cases 4, 5, and 7, after a comparatively symptom-free period of four and a half months, three months, and three and a half months, respectively, was another observation which was difficult to appreciate. The explanation of these peculiar behaviors probably lies in the realm of pathologic physiology and chemistry of the tissues, particularly the muscle, occasioned by the metabolic activity of *Endameba histolytica*.

#### REVIEW OF LITERATURE

Few references are available on the roentgen observations of intestinal amebiasis. Vallarino (5) found filling defects along the wall of the colon in all cases of amebic infection with definite symptomatology, whether mild or severe. These defects were present at the points of tenderness in the abdomen. He was able to determine the extent of involvement and found a valuable guide in the course of treatment. Occasionally, he found the lesion to be more extensive than the clinical symptoms indicated. As to the types of the defects, he mentioned "a mottling of the affected part," "loss of the normal contour of the bowel," and "in old cases, defects resembling obstructions." The most frequently involved portions according to this author were, first, the cecum and ascending colon, and, next, the sigmoid. Vallarino, in his first published article on this disease (5), expressed his preference for a barium meal by mouth, in the examination of the colon, over the direct injection of a barium enema. He appreciated the value of re-examination of the colon while under treatment, to determine the extent of improvement in the

lesions, as compared with the clinical improvement.

Henderson (6) observed few or no manifestations of spasm in the colon, in spite of the presence of numerous lesions, and he considered this finding to be of major importance in contrast to "the irritable cecum of tuberculosis and other ulcerative lesions." Henderson noted the bowel wall to be serrated with fine, saw-tooth or rose-thorn projections, suggesting the fringed gentian, and stated that "it is common to observe upon the plate the actual tunnel which is joining the base of two or more ulcers."

Both Vallarino and Henderson were dealing with chronic cases of unknown duration, and both considered the roentgen findings suggestive but not pathognomonic. Henderson, however, claimed that, in over 97 per cent of the patients exhibiting these roentgen findings, he was able to demonstrate *Endameba histolytica* in the stools, and that more than 60 per cent of these patients had shown no symptoms pointing in the direction of amebiasis.

Gunn and Howard (4), discussing the clinical resemblance to carcinoma of amebic granuloma of the large bowel, observed that the x-ray filling defects were produced by amebic thickening of the bowel, but felt that this usually involved such an extensive area of the intestine that the question of carcinoma did not arise. "However, occasionally such masses are localized and may readily cause confusion in diagnosis" and "not infrequently, the thickened bowel may be palpable through the abdominal wall. These conditions are usually encountered in cases of chronic amebiasis of long standing." The authors cited three patients in whom operative removal of an obstructing mass in the colon was done. The removed mass, in each instance, represented a large, hard, localized tumor of the colon, with central ulceration. In the first case, because of the extent of involvement as revealed on the roentgenograms and the fact that *Endameba histolytica* was demonstrated in the stools, a chronic amebic granuloma was

suspected rather than malignancy, while in the two remaining cases, a diagnosis of carcinoma of the cecum seemed justified because of the palpable mass in the right lower quadrant, with all other clinical

Such a confusion was recently experienced by a roentgenologist who made an x-ray diagnosis of carcinoma of the colon in an emaciated patient, with an enlarged nodular liver. The patient was a Spanish-



Fig 7-A Case 5 The colon three months after the institution of the first course of treatment. Note the marked spasm of the cecum and ascending colon.  
Fig 7-B Case 7 The colon three and a half months later. Note the marked spasm of the cecum and ascending colon.

signs of malignancy to support it. No roentgen findings in these two cases were recorded. However, the filling defects in the colon produced by any one of these three masses might well have been interpreted roentgenologically as carcinoma.

Harrison (7) reported such a patient, a native of Michigan, on whom was made a clinical diagnosis of carcinoma of the cecum, supported by the roentgen finding, interpreted as a cancer involving the hepatic flexure. The resection of the mass was impossible at operation due to the extent of involvement, but the thickened and indurated appendix was removed. *Endameba histolytica* was demonstrated in the appendix and was found in the stools, post-operatively. Whether or not a carcinomatous growth was the basis of the mass and the filling defect at the hepatic flexure, was not revealed. A co-existence of amebic dysentery and carcinoma must still be borne in mind.

American War veteran who, besides, gave a history of a Chicago visit in the Summer of 1933. He had had a previous roentgen diagnosis of probable amebic granuloma of the sigmoid, with obstruction, on the basis of the demonstration of *Endameba histolytica* in the material obtained from the lesion. The roentgenograms showed the typical deformity of an advanced cancer of the sigmoid. There was no clinical improvement under emetine therapy. Autopsy (12) revealed an ulcerating, annular carcinoma of the sigmoid, with massive metastasis to the liver, and also a small, solitary, early amebic ulcer about one centimeter in diameter, near the splenic flexure.

In case the involvement is found to be more diffuse, although the filling defects may be most marked in areas and the obstructive symptoms may develop as a result of localized narrowing of the lumen, a diagnosis of carcinoma is not likely to

be considered, roentgenologically. This is well illustrated by the first of the three cases reported by Gunn and Howard, already cited, as well as cases reported or cited by Desjardins (8), Vallarino (5) and others (9, 10, 11)

#### SUMMARY AND CONCLUSIONS

1 The roentgen appearance of the colon in amebic dysentery may vary considerably depending upon the stage of infection, the extent and degree of involvement, and the type of the lesion produced

2 On the whole, no appreciable changes are probably noted roentgenologically in the early stage of infection. Later, fine, saw-tooth projections may develop along the wall, which probably represent small superficial ulcers and which may soon become obliterated by inflammatory edema and exudation. Fine feathery or thorny filling defects on the indurated wall probably signify a later stage of the same lesion in which the submucosa and muscularis are involved in an extensive inflammatory granulation process

3 A somewhat characteristic deformity of the cecum and ascending colon is observed, roentgenologically, during the subacute or early chronic stage of the disease when there may be an apparent shortening or contraction of the wall, with induration and filling defects in varying degrees. These changes are rapidly eradicated by the institution of emetine treatment

4 An advanced amebic lesion, when diffuse and extensive, is not likely to be confused with cancer. When localized and obstructive, it may be mistaken for cancer, from which there is no roentgenologic means of differentiation

5 The roentgen appearance of the colon in amebic dysentery may be presumptive or suggestive of the disease but not positive or diagnostic, without collaborating clinical and laboratory evidences. On the whole, however, it does not resemble the usual picture of non-specific ulcerative or tuberculous colitis, nor does

it, as a rule, simulate the typical appearance of a cancer of the colon

6 The roentgen examination of the colon is a positive means of determining the location, extent, and degree of involvement in amebic dysentery and of observing the progress of the disease under specific treatment, from time to time. A small area of fresh involvement or the re-activation of old lesions may thus be demonstrated, roentgenologically, during a period of continued clinical improvement and negative or inconstant routine laboratory evidence. Thus, the roentgen examination of the colon may prove superior and more accurate than other means of demonstrating the presence of active lesions in the treated or proven cases of intestinal amebiasis. The value of the roentgen examination of the colon in this disease, therefore, lies more in its use as a guide in the general management of the patient than as a means of positive diagnosis

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# VISCERO-CARDIAC REFLEXES<sup>1</sup>

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IN his book, "Facts on the Heart," Cabot writes "The first and in some ways the most important point of all to remember is to know that most "heart disease" is imaginary. Those who think or fear that they have heart disease usually turn out, on careful examination, to be free from it. Whether or not this pseudo-heart disease, this groundless fear of heart disease is as common as I believe it to be, it is certainly common enough to make the thought of it an essential part of our mental furniture whenever we begin the examination of a supposedly cardio-vascular case. For the needless sufferings and sacrifices of such patients are very great. To my knowledge boys have given up their chosen life work, girls their prospect of marriage, business men their favorite projects, because of a false diagnosis of heart disease. The fears, disappointments, and ailments resulting from such a diagnosis may be enough to render a person's life miserable. And all this one can sweep away by a clear and positive reassurance based on a thorough examination. I know few greater services that a physician can perform, few that give him livelier satisfaction." Cabot's words might be appropriately paraphrased to read "There are 'few greater services that a roentgenologist can perform, that will give him livelier satisfaction,'" for often a definite diagnosis is possible only by means of a roentgen examination which may disclose unsuspected lesions remote from the source of the symptomatology.

The increase in the incidence of heart disease is causing much distress among the laity and many apprehensive individuals are consulting their physicians with complaints which are purely functional cardiac disturbances due to lesions and derangements of the abdominal viscera as well as

from other sources. In this era of "heart-consciousness" we are prone to overlook the fact that cardiac symptoms are not necessarily the result of cardiac disease *per se*.

Sir Henry Head early directed attention to the fact that pain in the left chest, particularly in the region of the heart apex, is often of cutaneous origin, due to a hyperesthetic segment of the cord caused by visceral stimulation of this segment. Weiss and Davis, in 1928, studying visceral pain, concluded that afferent cutaneous impulses bear a close relationship to the mechanism of visceral pain. They were able to abolish visceral pain completely by novocain anesthesia of the related skin segments and found that patients suffering from distinctly localized severe visceral pain were given prompt relief by infiltration of the corresponding skin area with novocain.

Experiments on animals have shown that when certain nerve pathways are severed it is impossible to induce premature contractions of the heart.

Schrager and Ivy have demonstrated reflex inhibition of the diaphragm, as a result of distention of the gall ducts, and have studied the pathway (right splanchnic and vagus).

Straus and Hamburger have shown that visceral disease may produce cardiac irregularities reflexly and have demonstrated that repair of the diseased viscus abolishes the irregularities. Babcock, likewise, has observed the effect of visceral disease on the production of cardiac irregularities and has discussed these observations at length. Rothburger produced extra systoles by stimulation of the vagus and sympathetic, after poisoning the heart muscle with barium chloride, and Levy has done likewise with chloroform. Recently Crittenden and Ivy have demonstrated experimentally that nausea, retching, and

<sup>1</sup> Read before the American Congress of Radiology, at Chicago Sept 25-30 1933

vomiting may cause in normal unanesthetized dogs cardiac irregularities such as heart blocks, cardiac arrests, ventricular and auricular ectopic beats. Pre-existing icterus increases the incidence of the irregularities, because icterus sensitizes the cardiac vagal mechanism.

The results of experiments designed to increase the irritability of the cardiac mechanism concerned in the production of arrhythmias by visceral excitation have corroborated clinical observations.

Some of the causes of referred symptoms to the precordium are Biliary tract disease, peptic ulcer, cardiospasm, mediastinal tumors, cervical rib, hyperthyroidism, herpes zoster, aerophagia, causing distention of the stomach and the colon, especially the splenic flexure.

Pardee recently called attention to osteoarthritis of the dorsal vertebræ, with resultant irritation of the dorsal nerve roots, as a cause of precordial pain.

Barnes, in a late issue of the "Proceedings of the Staff Meetings of the Mayo Clinic," reported a case in which a diagnosis of heart disease had been made by the home physician and the patient advised to stop work. At the Clinic a tentative diagnosis of angina pectoris was made. Part of the history was against such a diagnosis and a fluoroscopic examination of the stomach, requested by Dr. H. L. Smith, revealed a diaphragmatic hernia. The fact that the anginal pain occurred while at rest and was not induced by effort prompted x-ray examination of the stomach and a correct diagnosis resulted.

It is a common clinical experience to encounter patients with biliary tract disease, particularly cholelithiasis, subject, especially during attacks, to cardiac irregularities, the most frequent type being premature ventricular contractions. The following cases are briefly illustrative.

Case 1 M. G., a physician, 40 years old, suffered frequent attacks of upper right quadrant pain and during the attacks was conscious of premature contractions which he was well qualified to interpret. The frequency of the contractions was

greatly intensified when jaundice occurred. Roentgen examination revealed the presence of gallstones. After cholecystectomy in 1917 the irregularities were entirely abolished and have remained in abeyance since.

Case 2 E. G., a hospital orderly, 36 years of age, for two years had complained of frequent attacks of cardiac palpitation and a dull pain over the precordium. The attacks were of short duration and usually occurred during the night. The patient attributed his symptoms to the physical exertion occasioned by the nature of his duties and did not seek medical attention until he became jaundiced. The jaundice was first noted on arising on March 25, 1933. Other than this, there were no symptoms referable to the hepatobiliary or gastro-intestinal tracts. Roentgenograms of the heart and electrocardiographs, together with physical examination, disclosed no heart disease. A flat film of the gall bladder showed no visible stones. Cholecystography, however, revealed the presence of a persistent negative shadow which was diagnosed as a gallstone. At operation on April 4, 1933, a single small stone was found in the gall bladder and another in the common duct. Since cholecystectomy was performed there has been no recurrence of the palpitation or pain.

These two cases are clinical illustrations of the findings of Owen, Ivy, *et al*, namely, that biliary tract disease, especially when it produces jaundice, sensitizes the cardiac mechanism and is prone to induce these irregularities reflexly through a pathway which, their experiments indicate, involves the right splanchnic and vagus.

When a careful study fails to reveal cardiac disease it is then necessary to seek the causes previously mentioned, some of which can be revealed only by roentgen examination. (It must be emphasized here that in cardiospasm and esophageal lesions the roentgen examination must be made while the patient is having symptoms, otherwise disorders of this type may escape detection.)

Of the organic lesions responsible for the production of referred pain to the precordium, as with the irregularities, gall-bladder disease is the most common. It is a concomitant of coronary arteriosclerosis with angina pectoris in approximately 60 per cent of cases, and at times differentiation is most difficult. Biliary tract disease may direct its symptomatology to the precordium, producing pain quite typically anginal in character, even so far as to radiate into the left shoulder and arm. On the other hand, angina pectoris may cause symptoms simulating gall-bladder disease. Likewise, cardiac infarction and acute gall-bladder disease may occur simultaneously, as has been demonstrated by postmortem examination.

Because of the gas distention common to gall-tract disease, the vital capacity of the lungs may be lowered to such an extent as to give rise to dyspnea, which may erroneously point to cardiac trouble. The gas distress occurring shortly after meals may simulate so-called "acute indigestion," the misnomer under which coronary disease hid for many years.

It must also be remembered that angina pectoris may also be induced by overeating and the symptoms may be interpreted erroneously as being of gastric origin. Usually—and this is an important sign—the onset with effort is lacking in pure gall-bladder disease, but let us not forget that this does not hold true in all cases.

#### ABDOMINAL DISTENTION AS A CAUSE OF CARDIAC SYMPTOMS

Aërophagia, resulting in distention of the stomach and intestines with gas, may cause distress of sufficient severity to manifest itself solely in cardiac symptomatology. Recent experimental work on the reflex visceral mechanism substantiates the clinical observations of authors who have for many years ascribed paroxysmal auricular tachycardia to abdominal distention. Dyspnea, irregularities, palpitation, and precordial pain due to undue accumulation of gas, either of functional or organic

origin, may produce anxiety in patients sufficient to induce a fear of impending death. Rieder, basing his findings upon thorough roentgen investigation, believes that cardiospasm and spasm of the pars media of the stomach, together with pyloric insufficiency, are the factors that cause gastric and intestinal air distention, which produce, in turn, elevation of the diaphragm by the greatly increased pressure.

#### ILLUSTRATIVE CASES

Case 3 Mrs. M. H., age 27, of thin, neurotic type, suffered from attacks of abdominal distention for many years, especially in the left upper quadrant (splenic flexure). Roentgenologic study was negative except for the presence of a large amount of gas in the entire colon. Coincident with these attacks there occurred classical paroxysmal tachycardia which responded quickly to ocular pressure. The patient finally learned to avert many such attacks by prompt evacuation of the colon by means of an enema, as soon as she felt any discomfort. By this procedure the incidence of paroxysms was reduced from an average of twelve yearly to two during the past two years.

Case 4 Mrs. S. P. R., age 56, of nervous type, gave a history of attacks of precordial pain on effort, so much so that she was compelled to stop several times while walking on the street. Belching was profuse and afforded relief. Tachycardia and elevation of blood pressure accompanied the upsets. Physical examination, electrocardiographic and roentgenologic studies ruled out the presence of heart disease and tuberculosis. There was no evidence of hyperthyroidism. There was a large subdiaphragmatic accumulation of air caused by a distended stomach and splenic flexure, which was kinked. Relief was obtained by gastric lavage and flushing the colon.

Paroxysmal tachycardia occurs chiefly in a group of individuals who are of a highly neurotic temperament. It is probably true that these individuals have a cardiac

mechanism which has a low threshold to stimulation, since all persons do not suffer from tachycardia merely as a result of gaseous distention. The fact that this tachycardia is usually quickly terminated by vagal pressure in the neck or pressure on the eyeballs (ocular reflex of Aschner) points to its reflex origin and its connection with the pathways of the central nervous system. The pathways here in operation are probably the same as described by Ivy in his experiments, namely, right splanchnic and vagus.

It is not uncommon in abdominal distention to find sino-auricular bradycardia. Here the mechanism is most likely reflex through the cranio-sacral system. In ordinary sino-auricular tachycardia it is possible that the acceleration (sympathetic) mechanism is at fault, and likely this is entirely reflex in origin. Whether these two systems act independently or in algebraic summation probably depends on the threshold for stimulation of these systems in any one individual.

The action of these great systems is diametrically opposed, and it must be remembered that every viscus derives its supply from both.

Illustrative of sino-auricular tachycardia caused by gas distention is the following case.

Case 5 Mrs O, age 37, suffered frequent attacks of paroxysmal palpitation for which no cause could be ascertained after thorough clinical and roentgenologic study. At the time of roentgen examination she was free of symptoms. The patient stated that during the attacks she was greatly disturbed by gas and that belching afforded relief. To determine if its presence would precipitate an attack, air was introduced into the stomach under fluoroscopic control through a duodenal tube, until moderate distention occurred. The pulse rate prior to the introduction of the air was 68 per minute; shortly after the air was injected the patient complained of feeling faint and the pulse rate rose to 120 per minute. She commented that the symptoms experienced were similar to

those which prompted her to seek medical relief.

Therefore, in the course of roentgen examination of patients with cardiac symptoms the discovery of a large gas-bubble in the stomach or distention of the intestines causing left diaphragm elevation should not be ignored. Such a finding and its clinical significance should be stressed in the report of the roentgenologist. This may be the only means of excluding a false diagnosis of heart disease in this type of case.

#### SUMMARY

The history, physical examination, roentgenologic and cardiographic studies of patients with cardiac symptoms in many instances fail to reveal the existence of heart disease.

Cognizant of the numerous organic lesions and functional derangements of various organs that might produce heart symptoms reflexly, the roentgenologist may often determine the cause and establish a correct diagnosis by examination of the gastro-intestinal tract, lungs, mediastinum, and skeletal system.

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# EDITORIAL

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## RADIATION THERAPY

We have often wondered why so few physicians acquaint themselves with the indications for and uses of radiation therapy. It is apparent that a great number believe its use to be limited to a few diseases, and, at that, only as a palliative measure. Then again, there are some who have seen evidence of its effectiveness in the treatment of cancer, yet are reluctant to accept it or even to concede it its just place in the treatment of this disease. Surely this lack of knowledge is not due to sparsity of radiologic literature in this country, because we have at present two splendid radiologic journals issued monthly, publishing interesting scientific articles on irradiation therapy contributed by radiologists of international repute. The radiologic profession of this country is kept constantly informed of the latest progress in irradiation therapy as practised in this and other countries. There is also a not inconsiderable library of textbooks and atlases on radiology, which is constantly growing. Unfortunately, the splendid accomplishments in the cure of cancer with radiation therapy, resulting from long and continuous scientific research in the fields of physics and biology, are known to but few physicians. Of course, in a general way it is known that x-ray and radium are being used in the treatment of cancer, but few are familiar with the splendid results which are being obtained with these agents when used by experienced radiologists.

This branch of radiology has progressed rapidly in recent years, due in great part to the co-operation of engineers and physicists who have made it possible for American manufacturers to build x-ray apparatus of great magnitude and precision. Radiologists are now able to give most of their time and energy to a comprehensive study of the practical application of the very short wave lengths made possible by the new and powerful transformers. It is possible that internists and surgeons have not kept abreast of the accomplishments in radiation therapy, or noted the recorded cures. Radiologists, on the other hand, are

hesitant to report their results until they can speak with surety of 5-year cures. It is not uncommon, when addressing a general medical meeting, or even a class of students, on the subject of radiation therapy, to observe a smile of doubt, as much as to say, "Do you really believe this to be true? Well, I don't. You mean well, but you are an enthusiast." One of the main reasons for this apparent skepticism is that but comparatively few have informed themselves in regard to the application of x-ray and radium as therapeutic measures. In the case of students, to be sure, time and study may widen their horizon. While it is true that there is an abundance of radiologic literature on this subject, it is, unfortunately, read by a limited group of specialists. On the other hand, surgical literature on the treatment and cure of cancer finds its way to thousands of physicians practising all forms of medicine, through journals having wide circulation.

An example of the manner of disseminating such knowledge is found in the February, 1934, issue of "Surgery, Gynecology and Obstetrics." A symposium on the curability of cancer is presented in this issue and sponsored by a number of prominent surgeons. The interesting statistics thus presented on the 5-year clinical cure of cancer have reached the large number of physicians who are readers of this magnificent medical journal. It is inevitable that they will become more and more impressed with the value of the surgical treatment of cancer and less and less with that of irradiation therapy.

We have but words of praise for the editorial policy of "Surgery, Gynecology and Obstetrics" and the surgical contributors to this interesting symposium on the curability of cancer, which no doubt will enhance the value of surgery in the treatment of cancer. It is true that certain radiologic statistics are interspersed with the surgical ones, however, there are no radiologic statistics on the curability of cancer by radiation therapy alone as practised in the United States or Canada. The point is that, if the symposium is to cover adequately the field of curability of cancer, radia-

8 LEVI, R L Treatment of Cardiac Irregularities with Quinidine New York St Med Jour, 1924, XXIV, 18-21 Abstracted in Jour Am Med Assn, 1924, LXXXII

9 CRITTENDEN, P J, and IVY, A C A Study of Viscero-cardiac Reflexes, Am Heart Jour, 1933, VIII, 507-518

10 PARDEE, HAROLD E B Extra-cardiac Conditions Simulating the Anginal Syndrome Med Clinics of N A, July, 1933, XVII, 67-77

11 BARNES, A R Differential Diagnosis in a Case of Primary Carcinoma of the Bronchus and in a Case of Diaphragmatic Hernia Proc Staff Meetings of Mayo Clinic, Aug 23, 1933, pp 506, 507

12 OWEN, S E A Study of Viscero-cardiac Reflexes Am Heart Jour, 1933, VIII, 496-506

13 RIEDER, HERMANN (quoted by ASSMANN) Klinische Röntgen Diagnostik der Innere Krankheiten Leipzig, 1922, p 405

40 North Street

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## ANNOUNCEMENTS

## TWENTIETH ANNUAL MEETING

The Twentieth Annual Meeting of the Radiological Society of North America will be held in Memphis, Tenn., Dec 3-7, 1934, inclusive. The following Committees have been appointed, and they, with the co-operation of the members, are prepared to see the meeting through to a successful climax. This is none too early to lay plans to attend.

## General Arrangements Committee

W S Lawrence, M D, *Chairman*

Other members of this committee are the Chairmen of the various special committees

## Transportation and Commercial Exhibits

- (a) Charles H Heacock, M D, *Chairman*  
I S Trostler, M D (Chicago)  
A L L Bell, M D (Brooklyn)
- (b) Local Transportation Committee  
S W Coley, M D, *Chairman*  
J Cash King, M D  
James L Dubrow, M D

## Entertainments

- (a) Sports  
W R Bethea, M D, *Chairman*  
W B Anderson, M D  
W A Runkle, M D
- (b) Luncheon and Banquet  
R Paine, M D, *Chairman*  
W R Bethea, M D  
W S Anderson, M D
- (c) Ladies (Doctors' wives)  
Conley H Sanford, M D, *Chairman*  
Mrs W S Lawrence  
Mrs H N Pulliam

## Registration and Housing Committees

- (a) Hotel  
J Cash King, M D, *Chairman*  
Charles M Hamilton, M D (Nashville)  
John M Frere, M D (Chattanooga)
- (b) Registration Committee  
John H Herring, M D, *Chairman*  
Franklin B Bogart, M D (Chattanooga)  
I A Beale, M D (Greeneville)
- (c) Scientific Sessions  
Horace D Gray, M D, *Chairman*

Frank W Smythe, M D

John H Herring, M D

## Publicity and Education

M J Hubeny, M D, *Chairman* (Chicago)  
D A Rhinehart, M D (Little Rock)  
J Howard King, M D (Nashville)

## Scientific Exhibit

W W Robinson, M D, *Chairman*  
E R Rapp, M D  
W T Black, M D

## Clinic Committee

E G Campbell, M D, *Chairman*  
S S Marchbanks, M D (Chattanooga)  
Max Henning, M D

## PROGRAM OF THE NINETEENTH ANNUAL MEETING OF THE AMERICAN RADIUM SOCIETY

*Time*—Monday and Tuesday, June 11 and 12, 1934

*Place*—Empire Room, Hotel Cleveland, Cleveland, Ohio

- 9 00 A M Executive Session
- 10 00 Scientific Session  
Address of the President, Rollin H Stevens, M D, Detroit  
Symposium on Radium Dosage and Technic  
I Physical and Biologic Factors  
*Chairman*, George E Pfahler, M D, Philadelphia
- 10 20 Physical Determination of Radium Dosage, Otto Glasser, Ph D, Cleveland
- 10 30 Physical Factors in Teleradium Dosage, Wilhelm Stenstrom, Ph D, Minneapolis
- 10 40 Physical Factors in Intracavity Radium Dosage, James L Weatherwax, Ph D, Philadelphia
- 10 50 Physical Factors in Interstitial Radium Dosage, Edith H Quimby, Ph D, New York City
- 11 00 *Drosophila* Eggs for Radium Dosimetry, George Packard, Ph D, New York City (by invitation)
- 11 10 Clinical Considerations Influencing Radium Dosage, Maurice Lenz, M D, and J R Freid, M D, New York City

tion as well as surgery should be included in the statements. If the symposium covers only the narrower field of surgery in the cure of cancer, then it is in order for radiologists to report on their results in a symposium of their own. Yet there should be no rivalry between the two methods—that would be contrary to the very spirit of the medical profession. Let cures be effected by whatever methods are adequate; surgeons and radiologists are co-workers, not competitors. It should be remembered, however, that the cancer problem is as much a radiologic one as it is surgical, and radiologists can also report a substantial number of cancer cures by radiation therapy. To return to the symposium, certain statistics are reported by gynecologists, yet these, as might be expected, do not represent what is being accomplished in the hands of radiologists, and in a certain instance the reported statistics are of no value and place radiology in an unfavorable and unjust light. The author, in reviewing certain statistics from 1917 to 1926 in which radiation therapy was used in conjunction with surgery either pre-operatively or post-operatively, or both, in cases of radical operation for breast carcinoma, concludes that no material difference in the percentage of 5-year cures could be determined between the irradiated cases and those without irradiation therapy. Yet the same author in another part of his paper admits that the form of irradiation used does not compare with the present-day effectiveness of radiation therapy. He says: "The dosage of x-ray given in those years, however, was much more superficial and undoubtedly less effective than that used to day." Why make comparison between radiation therapy and surgery in such an instance? Why say that it was of no benefit, when it is admitted that the type used was ineffective? This can do irradiation only harm. We are convinced that the author had no such thought in mind when presenting his report, nevertheless those reading his statistics may accept his conclusions.

Radiologists are convinced that cancer is curable under certain conditions when all modern methods are employed by competent and experienced physicians, each in his own field.

What a great difference it would make if the general surgeon knew as much about the

principles of radiology as the general radiologist knows about the fundamental truths of surgery. It would do away with that feeling of skepticism which too often surgeons have toward irradiation therapy. They would learn that in many instances instead of losing cases, they would be the beneficiaries, as the medical profession and the public would learn that cancer can be more surely and more often cured by the combined methods of treatment.

We, as radiologists, know of the splendid results now being obtained in the treatment of cancer and other diseases by radiation therapy, but our knowledge of this fact is not sufficient—we must carry it to our medical confreres with accurate and indisputable proofs in the form of reliable statistical studies. No definite constructive effort has ever been made that we know of to gather accurate statistics on 5-year cures of cancer with radiation therapy. This should be done, the statistics to be gathered not only from a few of the outstanding radiologic clinics, but from all radiologists in therapeutic practice. A résumé of progress during the last few years, when it has accomplished so much, should also be obtained, all of which will not only serve as an educational survey for physicians seeking knowledge on this subject, but will be of incalculable value to the radiologists themselves who seek to improve their methods of treating disease with radiant energy.

Some may say that the time is not propitious for such a survey—that we should wait until we are all in agreement as to the best manner of attacking cancer with radiation therapy. We cannot share in such an opinion, for well-informed radiologists all over this country are using more or less standardized forms of therapy. In substantial proof of this, it is necessary only to refer to our radiologic literature. There is no better time than the present to initiate such a movement. It can do no harm and may do a great good. We owe it to cancer sufferers and to ourselves.

The Editor of RADIOLOGY is willing to initiate such a survey if the radiologists are interested. If they believe it to be a constructive idea, let them make known their reactions, whereupon we shall seek the co-operation of all radiological societies and set in motion the proper machinery.

Therapy, Ira I Kaplan, M D,  
New York City

## AMERICAN BOARD OF RADIOLOGY EXAMINATIONS

- 2 40 The Use and Abuse of Interstitial Radium Therapy, Albert Soiland, M D, Los Angeles
- 2 50 Hazards in the Use of Radium, J M Sittenfield, M D, New York City
- 3 00 Design of a Flexible Radium Bomb with Adequate Protection, Delivering a Homogeneous Field of Irradiation at Various Distances, William S Newcomet, M D, and B A Hughes, M D, Philadelphia (by invitation)
- 3 10 A Small Platinum Needle Designed for the Use of Various Strengths of Radium Element Interstitially, Norman Treves, M D, New York City
- 3 20 Correction of Dietary Errors in Connection with Radium Treatment, D T Quigley, M D, Omaha
- 3 30 Adenocarcinoma of the Oral Cavity, William L Watson, M D, New York City (by invitation)
- 3 40 Intraperitoneal Insertion of Radon and Gastro-enterostomy in Carcinoma of the Pyloric End of the Stomach, Isaac Levin, M D, New York City
- 3 50 Abdominal Implantation of Radon Seeds Combined with Removal of Iliac Glands in the Treatment of Cancer of the Cervix (28 cases), Fred J Taussig, M D, St Louis
- General Discussion Limited to 3 minutes each

The examinations of the American Board of Radiology will take place in Cleveland, June 10, 11, and 12, in Pittsburgh, Sept 22, 23, and 24, and in Memphis, Dec 1, 2, and 3, all of this year. Applicants should make inquiry from the Secretary-Treasurer, B R Kirklin, M D, Mayo Clinic, Rochester, Minnesota

## REPRINTS AVAILABLE

Dr I S Trostler wishes to announce that a few reprints of papers covered by Footnotes 1, 2, and 3 of his paper in this issue are obtainable by those interested. It is necessary only to send a large stamped self-addressed envelope to him, with the request

## BOOK REVIEWS

ROENTGEN ATLAS OF PULMONARY DISEASES (RÖNTGENATLAS DER LUNGENERKRANKUNGEN) An Introduction for Physicians by DR. W BREDNOW, Teacher of Internal Medicine and Roentgenology, University of Gottingen, and DR E HOFMANN, Roentgenologist for the City Hospital, Wuppertal-Barmen. Second edition, 207 pages, and 105 full-page roentgenograms. Published by Urban & Schwarzenberg, Berlin, 1933. Price not stated

The difficulties incident to the production of a satisfactory atlas of roentgen diagnosis, particularly in the field of pulmonary diseases, are well demonstrated in this volume. In spite of its 108 beautifully reproduced and well selected illustrations, there are numerous sins of omission. In so small a book the authors would have been better advised to have restricted themselves to the diseases of the lungs alone rather than to attempt to cover pleural and mediastinal conditions as well.

It is stated in the introduction that this atlas is intended especially for the practising physician, and, as such, it is quite acceptable. The excellent character of the illustrations and the brief but clear description of the cases are

## TENNESSEE RADIOLOGICAL SOCIETY

At the time of the recent meeting of the Tennessee State Medical Association, in Chattanooga, the radiologists of Tennessee met and organized the Tennessee Radiological Society, with the following officers

Charles M Hamilton, M D, of Nashville, *President*, Charles H Heacock, M D, of Memphis, *Vice-president*, Franklin B Bogart, M D, of Chattanooga, *Secretary-Treasurer*

The Society expects to meet annually at the time and place of the Tennessee State Medical Association meeting

- 11 25 Microscopic Structure of Oral Cancer and its Relation to Radiosensitivity, Arthur P Stout, M D, New York City (by invitation)

- 11 40 Microscopic Structure of Carcinoma of the Uterus and its Relation to Radiosensitivity, Charles C Norris, M D, Philadelphia  
Discussion opened by Francis Carter Wood, M D, New York City  
J E Gendreau, M D, Montreal, Canada  
George E Pfahler, M D, Philadelphia

*Monday, June 11, 1934*

*Afternoon Session*

- 2 00 P M Executive Session  
2 30 Scientific Session  
II Benign Lesions  
*Chairman*, Rollin H Stevens, M D, Detroit  
2 30 Benign Lesions of the Skin, Lawrence R Taussig, M D, and Howard Morrow, M D, San Francisco  
Discussion William S Newcomet, M D, Philadelphia  
2 45 Benign Lesions of the Uterus, James A Corscaden, M D, New York City  
3 00 Benign Uterine Hemorrhage, Henry Schmitz, M D, Chicago  
Discussion Charles C Norris, M D, Philadelphia  
Carl R Crutchfield, M D, Nashville  
3 15 Benign Lesions of the Eye, Ear, Nose, and Throat, Allen G Robinson, M D, New York City  
3 30 Chronic Infection of the Parotid Gland, G M Dorrance, M D, Philadelphia  
Discussion Zoe A Johnston, M D, Pittsburgh

*Annual Dinner*

7 00 P M, Monday, June 11, 1934

Rose Room, Hotel Cleveland

*Presiding Officer*, President Rollin H Stevens, M D

*Janeway Lecture*

Recent Advances in Experimental Cancer Research

Francis Carter Wood, M D, New York City

*Tuesday, June 12, 1934*

*Morning Session*

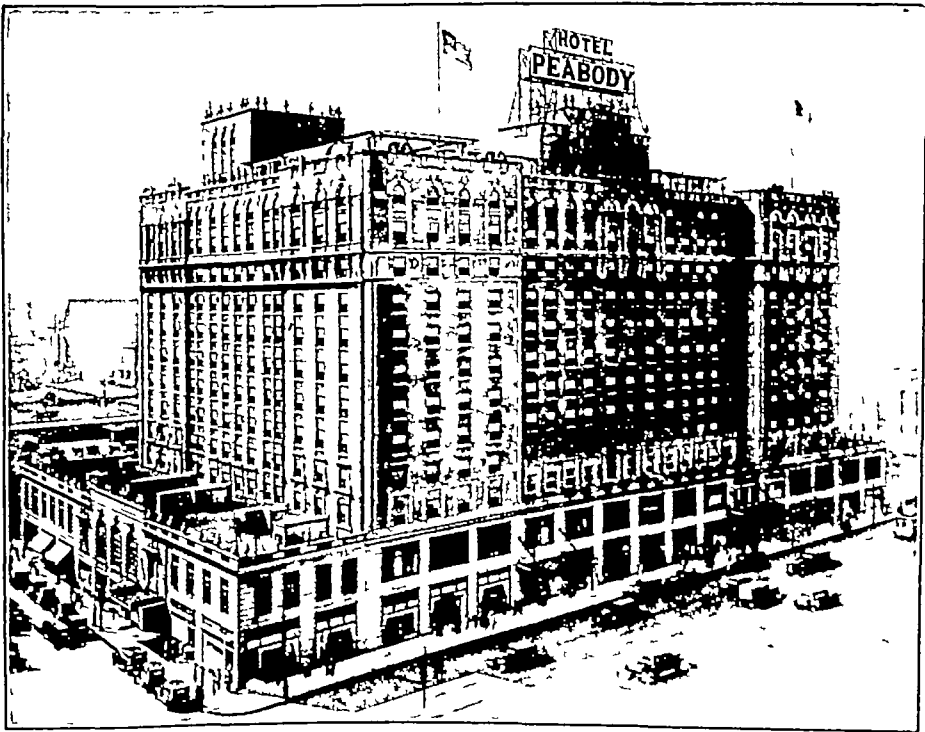
- 9 00 A M Executive Session  
9 30 Scientific Session  
III Malignant Neoplasms  
*Chairman*, George W Grier, M D, Pittsburgh  
9 30 Carcinoma of the Skin, Harold N Cole, M D, and J R Driver, M D, Cleveland (by invitation)  
9 45 Carcinoma of the Cheek, Hayes E Martin, M D, New York City, and Otto H Pflueger, M D, San Francisco (by invitation)  
10 00 Carcinoma of the Tongue, Frank E Simpson, M D, Chicago  
10 15 Carcinoma of Tonsil, Larynx, and Pharynx, Max Cutler, M D, Chicago  
10 30 Carcinoma of the Cervical Glands, Douglas Quick, M B (Tor), New York City  
10 45 Carcinoma of the Breast, Grantley W Tavior, M D, Boston (by invitation)  
11 00 Carcinoma of the Fundus Uteri, H H Bowing, M D, Mayo Clinic, Rochester, Minn  
11 15 Radium Treatment of Carcinoma of Cervix Uteri (Moving Picture Demonstration), Lawrence A Pomeroy, M D, Cleveland  
11 25 Carcinoma of the Bladder, Benjamin S Barringer, M D, New York City  
11 40 Carcinoma of the Rectum, William M Shedden, M D, Boston (by invitation)  
Discussion opened by George W Grier, M D, Pittsburgh  
General Discussion Limited to 3 minutes each

*Tuesday Afternoon, June 12, 1934*

- 2 00 P M Executive Session  
Election of Officers  
2 30 P M Scientific Session  
IV Miscellaneous Problems  
*Chairman*, J E Gendreau, M D, Montreal, Canada  
2 30 Complications and Injuries in Radium

The fact that this work is in Italian need not bar the English-speaking radiologist from reading it, for, as a matter of fact, anyone can get the gist of the subject matter, and the help of a little dictionary will enable one to follow

the text literally. The authors and publishers deserve great commendation for bringing out what your reviewer considers the best text-book on radiotherapy published up to date in any language



Hotel Peabody, Memphis, meeting place for the Radiological Society of North America, Dec 3-7, 1934



to be highly commended. The authors state frankly that they have not attempted to illustrate any but the most common types of pulmonary disease. Nevertheless, the complete omission of atelectasis, foreign bodies, iodized oil examinations, and the minimal consideration of other non-tuberculous inflammatory diseases leaves much to be desired. The pleural conditions are likewise treated inadequately, and the infrequent use of the lateral view is to be criticized.

The section on tuberculosis represents almost half of the volume, and on the whole, this disease is well presented. The authors' views on the development of parenchymal lesions and their classification in exudative, productive, and cirrhotic types are essentially sound. The plates illustrating the various manifestations of pulmonary tuberculosis, and the effects of different methods of treatment are excellent.

The details of technic and the description of the normal chest are briefly treated in the introduction. American roentgenologists will probably agree heartily with the warning that fluoroscopic examination will frequently fail to reveal minimal and moderately advanced lesions in the lungs. There may, however, be some disagreement with the authors' estimation of the value of paper film.

On the whole, this atlas is valuable as an introduction to the study of the roentgen diagnosis of chest diseases, particularly tuberculosis, for students and physicians who are inexperienced in roentgen diagnosis. For the mature roentgenologist it has relatively little to offer.

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A TEXT-BOOK ON ROENTGEN AND RADIUM THERAPY. Edited by FELICE PERUSSIA, Ordinary Professor of Medical Radiology of the Royal University of Milan, and ENZO PUGNO-VANONI, Extraordinary Professor of General Electrical Technic of the Royal School of Engineering of Padova. With the collaboration of Prof. O. Alberti, Prof. M. L. Asti, Prof. E. Bortoni, Dott. L. Gallavresi, Prof. F. Giongo, Dott. G. Giraudi, Dott. F. Mascherpa, Dott. G. Meda, Dott. M. Pellini, Dott. C. Picchio, and Prof. A. Ratti. Two volumes, about 1,600 pages, with many tables, 721 figures and illustrations (seven in colors). Fratelli Treves, Editori, Milan, 1934. Price, bound, 350 lire.

This is the most complete text-book on radio-

therapy published in Italian. It embraces with due and sufficient detail the physical and biologic fundamentals which underlie the clinical application of radiotherapeutic procedures without entering into the more theoretical or controversial questions with which many similar texts are loaded. It does not, on the other hand, seem to have omitted many things of actual importance. This nice balance has been reached by a well chosen linkage of many papers, each written by a specialist in his particular field, so that a well-rounded presentation results with each subject given its due prominence.

In the first volume (of 701 pages) Pugno-Vanoni takes up the fundamentals of the modern physical theory of radiations, then a review of apparatus and dosimetry, then Giongo discusses the emission and absorption of roentgen, and Asti of radium, radiation. Picchio complements these sections with some excellent tables, helpful in dosage problems. Gallavresi presents a fine consideration of the fundamental biologic concepts, and Ratti concludes with an exposition of the reactions and injuries likely to be encountered in radiotherapy.

The second volume (of 875 pages), which is clinical, opens with a general discussion by Perussia of the elements of the radiotherapy of tumors, which is elaborated and developed by Ratti. Benign uterine hemorrhage is discussed by Bortoni. Next Alberti takes up inflammatory disease, Giraudi, the treatment of tuberculosis, and Meda the lymphoblastomas and the diseases of the hematopoietic system. Pellini considers the field of internal medical diseases, then Mascherpa writes on the radiotherapy of diseases of the endocrine and nervous systems, Giraudi those of the bones and joints, and Perussia closes with an excellent discussion of radiotherapy in dermatology.

At the end of each chapter there is a bibliography of the important works in the field in point. Throughout the whole text extracts of clinical histories, supplemented by photographs (often in color) or radiographs serve to vivify not only the presentation of special clinical problems of radiotherapy, but also the special technic or apparatus required to carry out the treatment. The treatment is illustrated profusely with photographs and diagrams. Each volume has an excellent index which facilitates reference to items in the mine of information in the text.

The fact that this work is in Italian need not bar the English-speaking radiologist from reading it, for, as a matter of fact, anyone can get the gist of the subject matter, and the help of a little dictionary will enable one to follow

the text literally. The authors and publishers deserve great commendation for bringing out what your reviewer considers the best text-book on radiotherapy published up to date in any language



Hotel Peabody, Memphis, meeting place for the Radiological Society of North America  
Dec 3-7, 1934

# ABSTRACTS OF CURRENT LITERATURE

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H. P. DOUB, M.D., of Detroit, Michigan	DAVIS H. PARDOLL, M.D., of Chicago
J. E. HANDE, M.D., of Milwaukee	E. A. POHLER, M.D., Ph.D., of Madison, Wisconsin
H. W. HILF, M.D., of Milwaukee	CHARLES G. SUTHERLAND, M.D., of Rochester, Minn.

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## APPARATUS

A New Apparatus for the Improvement of the Protection of Radiologist and Technician when Working with Radio-active Substances W Schaefer and E Witte *Strahlentherapie*, 1933, XLVI, 568-573

A number of accessories are described which permit the preparation and handling of radium screens and plaques with a minimum of exposure to the hands of the operator The article is profusely illustrated

ERNST A POHLR, M D, Ph D

Electrical Accidents Critical Considerations about a Number of Electrical Accidents in Medical Roentgen

Laboratories G Grossmann *Röntgenpraxis*, April, 1933, V, 269-286, May, 1933, V, 354-363

During the last two years shock proof roentgen apparatus has been developed which does away with the dangers connected with the older type of apparatus Till the old apparatus for therapy and diagnosis is displaced by shock-proof installations the matter of electrical accidents is of great importance The author has collected 25 cases from the literature and the files of roentgen laboratories in order to investigate whether or not the rules and regulations published in the German "Fortschritte der Röntgenstrahlen," 1932, are sufficient to prevent such accidents Many accidents attributable to high tension currents have not been reported

in the literature, either because they did not cause much harm or because publicity was not desired

Of these 25 cases reported in this article, in nine the death of the person was caused by his coming in contact with the high tension wire. The description of the accidents, the suggestions to prevent them, and the conclusions reached by the author of this rather extensive paper are worth while reading for roentgenologists who still have to work with the old overhead type of high tension wires. The author believes that no such apparatus should be installed in any roentgen institute but that only shock proof apparatus should be permitted

H W HEFKE, M D

A New Apparatus for the Testing of the Seals of Radio-active Preparations E Witte *Strahlentherapie*, 1933, XLVI, 374-377

This is a description of an apparatus which easily permits the detection of leakage from a sealed radon applicator

ERNST A POHLE, M D, Ph D

Experimental Studies about the Photographic Treatment of Roentgen Films Richard Herz and Fritz Luft *Röntgenpraxis*, July, 1933, V, 520-529

According to a publication of Lewin, it should be possible to reduce exposure time to one fourth of the normal when the exposed films are submerged in water before developing and when they are frequently moved in the developing solution. The authors have repeated these experiments and have found that in the most favorable case the developing time might be reduced somewhat, but that it is not possible to shorten the exposure time by this method. They investigated also a fact known to photographers: the increase in contrast by exposing the film to a very small amount of light before or after exposure. Such an increase in contrast is possible but only with a loss of clearness. This method, therefore, can hardly be recommended except for certain occasions (for instance, extremities) when a slight haziness is of no importance

H W HEFKE, M D

A Special Fixation Apparatus for Intra-esophageal Radium Application Theodor Körner *Strahlen therapie*, 1933, XLVII, 557-561

The author describes an appliance which permits the fixation of a radium preparation in the esophagus. Photographs appended to the article show the construction and the use of the apparatus

Adjustable Protective Treatment Screen Géza Györgyi *Strahlentherapie*, November, 1933, XLVIII, 592-594

The author describes a protective device to be used in roentgen therapy, consisting of a stand with adjustable lead screen, particularly helpful in treating patients in the sitting position

ERNST A POHLE, M D, Ph D

The Operation of Therapy Tubes on Different Types of Apparatus Walther Müller *Strahlentherapie*, January, 1934, XLIX, 132-140

The author compared the circuits designed by Greinacher-Liebenow, Villard, and Witka, in x-ray therapy apparatus. He found that the first one mentioned, delivering almost a constant potential, is superior to the others

ERNST A POHLE, M D, Ph D

Detail and Sensitivity of Roentgen Paper H Chantraine *Röntgenpraxis*, April, 1933, V, 287-290

In roentgen paper not only the range of contrast is much narrowed, but the detail is also much lessened, when compared with roentgen films. Of the good qualities which the roentgen paper is supposed to have, there is only one really proved: that is its cheapness. However, if a thing costs little and is not worth more than it costs, there is no cause for praising it. The high sensitivity of roentgen paper does not help much. A high sensitivity should give good detail in moving objects, but the roentgen paper reproduces moving or quiet objects with equally poor result. If one wishes to be able to say that a record has been made, then one may let the roentgen paper take the place of a film. It is apparent from the above quotations that the author does not think much of roentgenograms made on paper

H W HEFKE, M D

## ARTHRITIS

Articular Osteochondromatosis of Reichel Antonio Masturzi *Archivio di Radiologia*, 1933, XII, Nos 5 and 6, pp 970-1005

Masturzi reports and illustrates 10 cases of this lesion in eight of which there was good evidence for accepting trauma as an important etiologic factor. Only one case gave evidence of arthritis deformans, another had an inflammatory lesion following trauma. Diagnosis of the lesion in question is possible only after roentgenologic study which, at the same time, will give invaluable criteria for the treatment

E T LEDDY, M D

Management of Gonorrheal Arthritis D W Hedrick *Am Jour Surg*, November 1933, XXII, 255-

Ammonium iodoxy benzoate is of definite value in the treatment of gonorrheal arthritis. It is best used as an adjunct to the usual orthopedic measures (1) short period of rest, preferably in plaster, for from four to ten days, (2) physical therapy, diathermy, massage, and active motion as soon as the pain disappears. In the milder cases its use permits a patient to be ambulatory who might otherwise be confined to the hospital.

Insufflation of the knee in the synovial type of gonorrheal arthritis is described. The author feels that it hastens resolution of the process, promptly relieves pain and thus permits early motion, preventing the formation of intra-articular adhesions and muscular atrophy from prolonged immobilization.

Aspiration, irrigation, or even drainage is sometimes necessary for the purulent type of infection, but amiodoxyl again seems to hasten the resolution and certainly relieves the discomfort. Splinting in a position of rest is necessary for a time, but early motion should be started as soon as the acute stage is over and pain is relieved. With this, diathermy and massage have been found to constitute the most valuable type of physical therapy.

Hyperpyrexia by fever diathermy is useful, especially in refractory cases.

Twenty-two cases are reported, 11 of which were treated with the adjuncts already described. Of these, 40 per cent were completely cured, 40 per cent much improved, and 20 per cent developed ankylosed but painless joints. The remaining 11 are presented for comparison and received no amiodoxyl, insufflation, nor hyperpyrexia therapy. Of these, 30 per cent showed no improvement, 10 per cent recurred, 20 per cent resulted in ankylosis, 40 per cent showed slight improvement.

DAVIS H. PARDOLL, M.D.

## BONE DISEASES (DIAGNOSIS)

Protruding Acetabulum and Accident. Fritz Berent. *Röntgenpraxis*, April, 1933, V, 303-306.

In two cases of characteristic protrusion of the acetabulum it could be shown that an accident which was supposed to be the cause had no bearing in it. In one case roentgenograms taken years before the accident had already shown a bilateral protrusion. There are cases of protrusion of the acetabulum, the etiology of which is unknown and which progress very slowly. Some cases show only moderate protrusion of the acetabulum into the pelvis, without deformity of the head of the femur or of the acetabulum itself. These patients complain of no, or very slight symptoms. In other cases there is marked destruction and deformity of all bones forming the hip joint. These patients have definite objective and subjective symptoms, similar to those from a complete ankylosis.

H. W. HEFKE, M.D.

Pathology of the Symphysis. G. M. Sack. *Röntgenpraxis*, August, 1933, V, 566-576.

Roentgenologic considerations of the symphysis have been greatly neglected. It has its greatest width during fetal life and decreases in width up to the tenth or twelfth year. From then on it remains about the same until old age, when it becomes still narrower. A great number of variations in the shape of the symphysis are normal. Some of the differences in shape apparent in roentgenograms, however, are due to the oblique direction of the central ray and to projection. The developmental anatomy as gone into by the author, includes old age and normal static stress which lead to anatomic changes of the symphysis just as in the spine. Pathologic changes are also caused by deformities of the pelvis and hips. A real joint might be found in a woman after several pregnancies. Osteoarthritic changes are common in advanced age, sometimes even forming osseous bridges. Degenerative changes in the ligaments are sometimes evidenced by areas of calcification. Complete bony ankylosis of the symphysis is not seen often in roentgenograms. Prolapse of cartilage (analogous to the Schmorl's bodies of the spine) has been seen by a pathologist, but is difficult to demonstrate on roentgenograms. Acute infections and tuberculosis of the symphysis are not rarely encountered, especially in puerperium. Trauma due to labor predisposes to it. Metastases of malignant tumors have been described, of primary tumors, chondrosarcomas are most frequently encountered. Ruptures of the ligamentous apparatus of the symphysis are seen after fractures of the surrounding pelvic bones or even in normal labor. Often separation of the pubic bone is combined with it, when the injury has been sufficiently severe.

H. W. HEFKE, M.D.

Post-traumatic Cystic Disease of the Carpal Bones. L. A. Malone. *Am Jour Roentgenol and Rad Ther*, May, 1933, XXIX, 612-616.

Instead of the many individual names applied to certain diseases of the carpal bones, such as Kienböck's disease, Preiser's disease, traumatic osteoporosis, traumatic malacia, secondary post-traumatic malacia, chronic osteitis, and osteodystrophia cystica, the author recommends the use of the single inclusive term of "post-traumatic cystic disease of the carpal bones." The trauma contributing to the process may be (a) abnormal pressure resulting from associated anomalies, (b) repeated minor occupational injuries, (c) severe trauma. Such trauma eventuates in permanent (or, more rarely, transient) disturbance of nutrition, and may be due to detachment of the ligamentum naviculolunatum, which contains the main nutrient vessel, or to interosseous hematoma formation. Conditions to be differentiated are tuberculosis, syphilis, non-specific arthritis, congenital anomalies, central bone abscesses, and tumors. The author presents five cases, in three of which cystic changes were present.

in both the navicular and lunate bones. In two of the cases, there had obviously been old ununited fractures of the navicular in addition to the cystic changes.

J E HANNE, M D

## BONE DISEASES (THERAPY)

Osteosclerosis of the Pelvic Bones as an Early Symptom of Osteitis Deformans (Paget) Franz Polgár *Röntgenpraxis*, July, 1933, V, 487-494

Barsony and Polgár described, in 1928, an osteitis condensans ilia which is typified clinically by sacro-iliac symptoms and pain radiating into the lower extremities. Roentgenologically it shows a more or less extensive osteosclerotic process of the os ilium, usually beginning just beside the sacro iliac joint. Sometimes the superior ramus of the os pubis is the only bone attacked. The thickening of the cortex is uneven in some cases (periosteal bone apposition). In one case the author had occasion to demonstrate a definite advance of the changes in five years. There may be not only productive bone changes but also regressive changes (decrease of calcium content in some areas and formation of cyst like spongiosa spaces). The opinion of the author at present is that this osteitis condensans is a forerunner, and an initial stage, of Paget's disease of the pelvic bones. Pathologic anatomic studies are not available as yet.

H W HEFKE, M D

Roentgen Therapy of Tuberculosis of Bones and Joints H Holfelder *Strahlentherapie*, December, 1933, XLVIII, 771-775

Roentgen therapy of tuberculosis of the bones and joints has been successful in the author's clinic. The single dose amounts to from 130 to 150 r (in air). The more acute the process, the smaller the dose. Some cases, with marked abscess formation and fistula, may require from 300 to 450 r. Deep therapy technique should be used.

ERNEST A. POHLF, M D, Ph D

Osteomyelitis of the Ilium Carl E Badgley *Arch Surg*, January, 1934 XXVIII, 83-124

The author finds a very scant literature on this subject, especially on the chronic type of osteomyelitis of the ilium. He reports 24 cases of this condition out of which number 17 have been completely cured.

Resection of the wing of the ilium was done 12 times; partial resection of the anterior or posterior thirds in 5 cases; removal of the outer table of the ilium, accompanied by saucerization of the ilium, in 4 cases; sequestrectomy and drainage in 1, and saucerization of an abscess just above the acetabulum in 2. In most cases of chronic osteomyelitis of the ilium, the author advises resection of both tables of the bone but it is

rarely necessary to do a complete resection of the bone. A very thorough discussion of all the clinical features of this condition is given in the body of the article.

HOWARD P DOUB, M D

## BRAIN

Cranial Osteomas and Hyperostoses Produced by Meningeal Fibroblastomas A Clinical Pathologic Study Francis Echlin *Arch Surg*, February, 1934, XXVIII, 357-405

Cranial osteomas may be either spongy or eburnated and arise from pre-osseous tissue on the cranial surface as a rule, early in life. They most frequently involve the frontal bone and are very slow in their growth.

The spongy type of osteoma usually causes an absorption or spongy transformation of the outer table of the cranium and becomes continuous with the diploe. This often depresses the inner table of the skull in this region, but usually does not cause compression of the brain. This type of osteoma has often been described as arising from the diploe.

Osteomas of the cranial surface rarely arise in adults and then tend to be of a dense, eburnated type.

Hyperostoses produced by meningeal fibroblastomas can be distinguished from osteomas of the cranial surface prior to operation. Osteomas usually occur in youth and hyperostoses in the fourth decade of life. Compression of the brain commonly accompanies hyperostoses, but is rarely present with osteoma. The roentgenographic appearances are also different.

Osteomas that cause severe pressure on the brain usually arise either about the paranasal sinuses or the orbits or from the inner surface of the skull and not in the periosteal region on the cranial surface.

HOWARD P DOUB, M D

The Roentgenologic Diagnosis of Brain Tumors Godehard Gornalewski *Röntgenpraxis*, July, 1933 V, 506-514

There is nothing new in this article, but it contains a short history, clinical findings, and reproductions of roentgenograms in nine cases of brain tumor and related lesions. In many cases the roentgenologic diagnosis is very much dependent on the clinical findings. In some cases special positions must be used, as Stenver's for demonstration of the petral portion of the temporal bone. In other cases neither the commonly used nor the special roentgenograms are sufficient for localization and encephalography (ventriculography) has to be done. The differentiation between hemorrhage and tumor cannot always be made clinically or roentgenologically—there is still much to be learned. The new method of arteriography and the injection of intracysternal contrast media are methods which possibly promise a new advance.

H W HEFKE, M D

## CANCER (DIAGNOSIS)

Carcinoma of the Penis in Siam T P Noble  
British Jour Urol, September, 1933, V, 242-248

The author states that the estimates of the frequency of cancer in the East are open to fallacy because of the lack of an adequate system of registration of deaths, but in the case of a particular disease, fairly reliable conclusions can be reached from hospital admissions

Cancer of the penis formed 9.6 per cent of the total admissions for cancer to the Sirraj Hospital during the four years under review Phimosis appears to play the chief rôle in the etiology of this disease, and syphilis as a causative factor comes second The inguinal glands, although usually enlarged, are rarely the site of a secondary cancer, according to the author

DAVIS H PARDOLL, M D

Primary Malignant Disease of the Duodenum  
Sherman A Eger Arch Surg, December, 1933, XXVII, 1087-1108

Primary carcinoma of the duodenum, which is almost as frequent as carcinoma of the jejunum and ileum combined, is found in 0.033 per cent of autopsies, making the ratio of 1 to 2,780 Of the three duodenal portions, the second, or ampullary, is by far the most frequently involved Cylindric cell adenocarcinoma is the type most frequently found There is little evidence that duodenal malignancy arises from a simple duodenal ulcer Metastases, even to the contiguous lymph nodes, are not common and occur very late in the disease The diagnosis is difficult, owing to the lack of clear-cut clinical findings

The course of the disease is usually progressive and rapid Radical excision should be performed in uncomplicated cases

HOWARD P DOUB, M D

Epithelioma of the Auricle and Carcinoma of the Stomach Edmondo Ingber Arch di Radiologia, 1933, XI, Fasc 3, pp 418-432

Ingber reports a patient in whom the occurrence of two carcinomas brings in the problem of their interrelationship—whether they were two independent tumors or whether the one in the stomach was a metastasis from the ear lesion

E T LEDDY, M D

## CANCER (THERAPY)

Results of Radiation Therapy in Inoperable Carcinoma of the Cervix Ivan von Büben Strahlentherapie, January, 1934, XLIX, 82-91

The author states that 305 cases of inoperable carcinoma of the cervix, out of a total of 658, were free from symptoms for one year (45 per cent) following radiation

therapy Thirty-eight patients remained well for five years, corresponding to a clinical cure of 9.8 per cent. Radium was applied in two screens of 25 mg each, filtered through the equivalent of 1.5 mm Pt, and left in the uterus for from 24 to 48 hours X-ray therapy was given with the following technic 190 K V, 0.5 Zn + 0.5 mm Al, 30 cm F S D, 3 to 6 fields, 1,500 r per area The patients are examined at regular intervals

ERNST A POHLE, M D, Ph D

Combination of Radiation Therapy with Hormone from the Anterior Lobe of the Hypophysis in Carcinoma of the Female Genital Organs Georg Ernst Strahlentherapie, November, 1933, XLVIII, 552-561

The author studied the combined effect of hormone of the anterior lobe of the hypophysis, and irradiation, in cases of malignant disease of the female genital organs He could not find any definite beneficial effect of the hormone treatment The latter was, however, very effective in cases of ovarian dysfunction

ERNST A POHLE, M D, Ph D

Results of Cancer Therapy in the Dermatological Clinic of the University of Zürich G Miescher Strahlentherapie, January, 1934, XLIX, 65-81

The author compares the results obtained by the single massive and fractional dose methods in the treatment of skin cancer He administers from 1,200 to 1,600 r, calculated for a field of  $4 \times 4$  cm, without filter, or filtered through from 0.5 to 1.0 mm Al for superficial carcinoma, and from 0.1 to 2.0 mm Cu for deeply infiltrating carcinoma The fractional doses amount to from 200 to 220 r in each sitting, giving a total of from 16 to 24 exposures, or from 3,800 to 4,600 r per field The penetration of the radiation varies according to the depth of the lesion Numerous tables are shown, on which the conclusions drawn from this study are based It appears that the percentage of cure for skin cancer not exceeding 2 cm diameter, obtained by the single massive dose method, is from 94 to 96.5 per cent Carcinoma of the lip belongs to the same category For larger tumors, the fractional dose method is the method of choice

ERNST A POHLE, M D, Ph D

## CONTRAST MEDIA

Varicography Maurice M Pomeranz and Isidor S Tunick Surg, Gynec and Obst, November, 1933, LVII, 689-695

The authors discuss the visualization of the venous system of the extremities, in living patients, by the injection of skiodan The study included both normal and abnormal veins examined with the patients in the upright, vertical, and Trendelenburg positions

The technic employed consisted of the injection of



from 5 to 20 c c of a 40 per cent solution of skiodan. The patient should have the usual preparation for intravenous injection, and care should be taken not to inject the solution into the surrounding tissues. The use of the tourniquet is optional unless it is desired to employ the Trendelenburg test, in which case a tourniquet is essential. If an ulcer exists in the case of pathologic veins, it is desirable to mark the location of the ulcer by means of a radiopaque marker. The authors suggest stereoscopic films, along with the usual fluoroscopic examination, for a complete study of the venous system.

Normal veins pursue a straight course with gentle curves but without kinks or tortuosities. The caliber is uniform and the terminal filaments taper off gradually. Spasmodic constriction may be noted as the result of chemical irritation. The authors were able to study the valvular apparatus best in the normal veins of the arm, the valves being situated distal to the point of entrance of the communicating veins.

In the case of abnormal veins this study revealed pathologic changes to a degree unsuspected by the physical examination. With dilatation and an apparent increase in length, loops and coils were noted, which extended in all directions. Venous pools were found to be commonly present in the vicinity of ulcers. It was also noted that many vessels became occluded by this procedure but no ill effects were observed in any case.

During the course of this investigation, the authors injected a large venous angioma with skiodan with good results, the venous dilatation being so marked that it formed a large unsightly tumor. The patient had refused operation. Radiographic examination showed the tumor to consist of innumerable convoluted, dilated vessels, closely intertwined. Of interest is the fact that three days after the injection practically complete obliteration of the angioma was noted.

J N ANÉ, M D

Excretion Urography, with Particular Reference to Newly Developed Compound Sodium Orthiodohippurate. Moses Swick. Jour Am Med Assn, Dec 9, 1933, CI, 1853-1855.

The underlying principle of the present investigations concerns itself with the utilization of a normal product of metabolism as an organic nucleus for combination with the radiopaque element necessary for the visualization of the urinary tract. This substance is a newly developed compound sodium orthiodohippurate, a halogen derivative of a compound normally found in the human urine. On the basis of its use in more than 200 cases the author has found the substance to be non-toxic, highly soluble, and neutral in solution and to yield satisfactory urograms. It possesses 38.8 per cent of iodine in stable organic union. Iodism has never been observed. Generalized warmth and occasionally nausea and vomiting of very transient duration have been the only reactions noted. Thrombosis at the site of injection has not been observed. A

solution of this substance remains unchanged in color or reaction after sterilization or on standing, and may be prepared and distributed in sterile vials ready for use. For adults a dose between 10 and 15 gms of substance dissolved in distilled water in approximately 50 per cent concentration has been used. Both intravenous and oral administration have yielded satisfactory results. The technic of administration by both methods is given in detail.

C G SUTHERLAND, M D

Huge Perforation of the Duodenum, with the Escape of the Opaque Meal. M. Lambrazzi. Arch di Radiologia, 1933, XI, Fasc 3, pp 468-480.

The author presents a case of duodenal ulcer perforating into the liver in which the clinical diagnosis was difficult, if not impossible, to make. As the result of gastro-intestinal examination, using barium sulphate a large hepatic perforation was demonstrated, while another examination a short time before had showed an ulcerating lesion in the bulb.

E T LEDDY, M D

Iodized Oil in Bronchiectasis, Including Study of Two Cases Following Lobectomy. J A Weinberg. Arch Surg, September 1933, XXVII, 545-564.

The author reports observations on two patients who had injections of iodized oil at intervals before lobectomy. He also gives the results of experiments on animals regarding the distribution of the oil and its effect on the lungs.

He believes that all types of cells in the lungs participate in the taking up of the oil droplets. The oil remains in the lung tissue for a period of at least 83 days following the injection. In bronchiectasis, it is probable that many of the sacs of the diseased lung fail to receive oil, according to the findings in the human lung described here. Experiments on animals show that injection of iodized oil into the bronchial tree results in multiple areas of atelectasis, a condition which usually subsides after a period of two weeks. Several of the animals died from 40 to 52 days after injection. All of them showed extensive pneumonitis due probably to the excessive amount of iodized oil which was injected. The occurrence of atelectasis and pneumonitis indicates that very small amounts of iodized oil should be used for diagnostic purposes in clinical work. In experimental animals, iodized oil is retained for a much longer period in the bronchiectatic lung than in the less diseased lung.

HOWARD P DOUB, M D

## DIAPHRAGM

Physiologic Variations in the Contour of the Diaphragm Simulating Organic Disease. Harry A Singer and William S Bonkan. Am Jour Roentgenol and Rad Ther May, 1933, XXIX, 600-606.

Generally speaking, distortions in contour of the regulation diaphragmatic arc are considered invariably due to supra- or infra-diaphragmatic disease. There are normal physiologic variations which are not, however, generally recognized to be such. One type consists in the presence of a distinct antero-medial bulge (always right-sided). The double explanation of this normal variation (which in exaggerated form may occur in the presence of certain pulmonary lesions) is (a) a disturbed relationship of muscular development of the component muscle fibers, those in the posterolateral group being relatively stronger than the fibers on the antero-medial group, (b) the medial portion is inhibited in descent because of its relative fixation above to the inferior vena cava which passes through it. The other major type of contour deformity (predominantly right-sided although sometimes manifest on the left side, also) is individualization of the costal components, dependent upon the variable development of the muscle bundles arising from the lower six ribs. The resulting appearance is a series of digitations, with the scallops pointing downward and a step-like lateral ridge formation at the costophrenic angle. The phenomenon of digitization is ascribed to hypertrophy of the costal bundles, and is to be observed in athletes and in cases of compensatory hypertrophy of one side of the diaphragm in disease of the other.

Illustrations of these physiologic variations in diaphragm contour are given to show the importance of their recognition and correct interpretation.

J E HABBE, M D

### GALL BLADDER (NORMAL AND PATHOLOGIC)

Changes in the Shape of the Gall Bladder by the Formation of Diverticula. W Nagel. *Röntgenpraxis*, September, 1933, V, 653-659.

Changes in the shape of the gall bladder are mostly caused by pressure pull, or fistula formation from neighboring organs (liver, duodenum or colon). Congenital membranes, the ligamentum cystico-duodenale, cystico-colicum and hepato-cystico-colicum may also be responsible. Duplication of the gall bladder or septum formation are very rare (1 in about 3,000 or 4,000 cases). A kink in the fundus might lead to an S-formation or a gall bladder of spiral shape. Deformities caused by spasm may be excluded by antispasmodic drugs. Diverticulum like deformities have been described in the roentgenologic literature. Their cause may be spastic contractions, excessive dilatation of Luschka's ducts, folds of the mucosa, or adhesions.

Two cases of diverticula of the gall bladder are described by the author. In the first case the roentgenologically demonstrable diverticulum was at operation seen to be due to adhesions and to a gallstone. In the second case the fundus diverticulum was caused by adhesions from the gall bladder to the duodenum, which was the seat of a chronic duodenal ulcer. It seems necessary to exclude a congenital diverticulum,

which is of no clinical importance, and to try to find the anatomic cause for the deformity either in the gall bladder or in the surrounding organs.

H W HEFKE, M D

A Contribution to Cholecystography. A Pirazzoli. *Arch di Radiologia*, 1933, XI, Fasc 3, pp 433-467.

Pirazzoli used the "rapid method" of cholecystography (which was introduced by Antonucci) in the study of 165 cases with symptoms of gall-bladder disease, and of this group 50 had operative control. This method is also of value in the study of cholelithiasis and of the mechanism of emptying the gall bladder.

E T LEDDY, M D

Double Formation of the Gall Bladder in Humans Demonstrated Cholecystographically. W Braunschweig. *Röntgenpraxis*, August, 1933, V, 594-596.

Complete duplication of the gall bladder is rare, such an occurrence having been seen in roentgenograms only once, in a case described by Climan. Reproductions of oral cholecystograms show the presence of two gall bladders—best on the film taken twenty minutes after giving eggs for emptying the gall bladder. Each gall bladder seems to have a separate cystic duct. In some of the roentgenograms the condition could easily be mistaken for other malformations, as diverticula.

H W HEFKE, M D

### GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Compression and Dislocation of the Digestive Tract in Some Abdominal Affections. Mario Muzzi. *Archivio di Radiologia*, 1933, XI, No 4, pp 643-681.

Muzzi reports 24 cases in which there was extrinsic compression of various organs, illustrates their radiologic appearance, and points out some of the difficulties that may be encountered in diagnosing the exact nature of the deformity or displacement of the viscus.

E T LEDDY, M D

Segmentary Spasm of the Lesser Curvature of the Pyloric Antrum in the Diagnosis of Ulcerative Lesions in the Pyloroduodenal Region. Gaetano Colale. *Archivio di Radiologia*, 1933, XII, Nos 5 and 6, pp 1045-1060.

Colale describes a particular spasm of the pyloric antrum which he regards as almost pathognomonic of ulcerative lesions in the outlet of the stomach.

E T LEDDY, M D

Hypertrophy of the Pyloric Muscle of Adults. A Distinctive Roentgenologic Sign. B R Kirklin and Milo T Harris. *Am Jour Roentgenol and Rad Ther*, April, 1933, XXIX, 437-442.

At the Mayo Clinic in the five-year period from 1927

to 1931, 81 cases of benign hypertrophy of the pyloric muscle were encountered, as proved by operation. Only one of the cases was correctly recognized at roentgenologic study prior to operation, but on reviewing the films the authors are convinced that the findings of elongation of the pyloric ring, plus crescentic indentation of the base of the bulb, constitute pathognomonic appearances. In 51 of the 81 cases, there were associated lesions such as peptic ulcer, duodenitis, chronic cholecystitis, or chronic appendicitis. Hence, the etiologic relationship between prolonged pylorospasm and benign hypertrophy is suggested.

J E HABBE, M D

The Roentgen Diagnosis of Right Paraduodenal Hernia. Report of a Case, with Survey of the Literature. Frederick B Exner. *Am Jour Roentgenol and Rad Ther*, May, 1933, XXIX, 585-599.

The four regions in the posterior abdominal wall in which hernie are apt to occur are (1) the lesser peritoneal sac, (2) the intersigmoid fossa, (3) one of the fossae about the cecum, (4) one of the fossae about the duodenojejunal flexure. This last type of hernia may be subdivided into the right and left types, of which the former is the less common. Only two authenticated cases with pre-operative diagnosis have been reported prior to this time. In the small series of 40 cases of right paraduodenal hernia accepted by the author, the ratio of males to females was 5 to 1. It is characteristic of both right and left paraduodenal hernie that they usually contain almost the entire small bowel.

The most characteristic sign of right paraduodenal hernia is a clumped appearance of the small intestinal coils as if contained in a bag, such arrangement being unchanged by manipulation or change of position. The axis of the mass of herniated loops is somewhat to the right of the midline. Only the body portion of the stomach tends to be displaced down to the left. There tends to be an absence of the small bowel in the pelvis, and the lower margin of the bowel area is convex downward instead of concave downward as in pelvic tumor. There is apt to be more or less stasis in the small bowel.

The author's case was that of a female, aged 56, who clinically showed carcinomatous masses in the pelvis and a marked ascites. Her gastro-intestinal symptoms were attacks of pain in the right upper quadrant, intermittent bloating, and some constipation. The x-ray findings were (1) by *enema*, pressure on rectum, slight upward displacement of sigmoid, slight medial displacement of the ascending colon, dilatation and upward displacement out of the pelvis of the terminal ileum, (2) by *barium meal*, clumped arrangement of much of the small bowel in the right mid-abdomen with, however, some dilated gas-filled loops high in the left abdomen, at nine hours, visualization of a loop of ileum near the duodenojejunal flexure, showing a sudden transition from wide to narrow

caliber, interpreted as the efferent loop passing from the sac.

Operation confirmed the diagnosis of probable right paraduodenal hernia and the herniated bowel was easily reduced, but repair of the sac was not done because of the pelvic condition.

J E HABBE, M D

## GENITO-URINARY TRACT (DIAGNOSIS)

Practical Application of Excretory (Intravenous) Urography. William F Braasch. *Jour Am Med Assn*, Dec 9, 1933, CI, 1848-1852.

"Excretory urography" would seem to be the logical term, since it is physiologically descriptive and, in view of recent and portending advances in oral administration, would be quite acceptable. Many of the deformities of the renal pelvis will soon be roentgenologically standardized in a manner similar to lesions of the alimentary tract, so that any one with roentgenographic experience should be able to interpret most urograms with a fair degree of accuracy. Errors in interpretation undoubtedly will arise and the necessity for correlation with cystoscopic and other data will often be present. The excretory urogram will be of greatest practical value to clinical diagnosis in (1) determining the presence of stasis in the renal pelvis or ureter, (2) aiding in interpretation of shadows in the upper part of the urinary tract, and (3) giving a fairly accurate estimate of renal function. Retrograde urography is still of great value, particularly in the recognition of minor deformity, and supplies data that cannot be acquired by any other method. The data obtained from the combined use of excretory and retrograde urography will often give more complete information than when either method is used alone.

Excretory urography is frequently disappointing because of inadequate visualization of the pelvis and calices. Complete failure of visualization on one side in repeated films must be interpreted as indicative of renal dysfunction. Many cases of hydronephrosis will be diagnosed by the general practitioner which otherwise might be overlooked. The comparative degrees of ptosis and of the excursion of both kidneys in varying positions can be determined more accurately in the excretory urogram.

Excretory urography is probably more often of value to the general practitioner and surgeon in the diagnosis and study of lithiasis than in any other field. The excretory urogram will often give sufficient data either to identify abdominal tumor as renal or to exclude the possibility of its being renal. Excretory urography, when feasible, is distinctly preferable to retrograde urography in the diagnosis of polycystic kidney.

Various observers have employed this method as a routine without apparent injury to the patient and have been able to find evidence of secondary lesions in the urinary tract in a surprisingly high percentage of cases.

C G SUTHERLAND, M D

Urethrocytography in the Male Joseph A Hyams, Herbert R Kenyon, and Samuel E Kramer Jour Am Med Assn, Dec 23, 1933, CI, 2030-2035

Because of the close anatomic and functional relationship of the posterior urethra, adnexa, vesical neck, and bladder muscle, a more accurate concept of their morphology and function can be obtained by their simultaneous and complete delineation than from urethrography or cystography alone. Previous experience enabled the authors to develop a technic for the performance of urethrocytography by combining several procedures previously advocated by other workers with a simplified manometrically controlled syringe they devised. The technic and apparatus are described in detail. Interpretation is discussed. Advanced chronic urethritis is manifested by fairly definite changes. Demonstration of the accessory urethral structures is of diagnostic importance, normal adnexal structures do not readily permit entrance of the injected fluid. Flattening of the bladder base and irregularities in its contour may express the severity and extent of prostatic involvement. The diagnostic value in stricture of the urethra, and in benign and malignant lesions of the prostate, with its utility in observations following operations for vesical neck obstructions are discussed in detail. The authors have adopted the use of watery solutions because, in addition to fulfilling all the requirements of a satisfactory medium, they penetrate readily into the smaller canals and pockets. Iodized oils do not possess these advantages. The combined method has adequately demonstrated bladder, urethral, and adnexal changes and has proved less expensive, less time-consuming, and more satisfactory as a routine diagnostic method.

C G SUTHERLAND, M D

Solitary Cysts of the Kidney A Review of Co-existing Pathology Boris E Greenberg, M Leopold Brodny, and Samuel A Robins Am Jour Surg, February, 1934, XXIII, 271-283

Ten solitary cysts have been encountered during the past four years on the urological service of a hospital having a capacity of 185 beds.

The etiology of solitary cysts remains undetermined. Within the last year, Hepler presented very careful experiments which advanced the theory of infarcts and tubular obstruction as factors producing these cysts. However, the experiments of Latteri, in which he produced solitary cysts by implanting fragments of the mucosa of the ureter or renal pelvis into the kidney parenchyma, added additional strength to the theory of congenital pathogenesis.

The clinical diagnosis of solitary cyst is possible. With better x ray facilities, the diagnosis can be more frequently made, yet in the absence of adequate urologic studies the diagnosis is often unsuspected.

Intravenous urography intensifies the roentgenographic outline of cysts, and will often demonstrate changes in the size and shape of the kidney which are not observed in retrograde pyelography.

In about 40 per cent of the kidneys which contain solitary serous cysts, additional pathologic lesions are present. Two cases of tumor of the kidney, two cases of renal calculi, and one case of cyst of the liver co-existed with a solitary cyst of the kidney in five of the ten cases reported in this paper. It is important that these co-existing lesions be recognized pre-operatively, and a plan of treatment instituted in accordance with the accepted methods for the type of lesion present.

DAVIS H PARDOLL, M D

New Pyelographic Technic Miley B Wesson Am Jour Surg, February, 1934, XXIII, 284-286

After a routine kidney investigation, while the catheters are in position and plugged, intravenous pyelograms should be made. The patient will not be subjected to kidney colic due to pelvic irritation, and clear-cut urograms, in addition to a good outline of the kidney substance, will be obtained.

DAVIS H PARDOLL, M D

## GENITO-URINARY TRACT (THERAPY)

Spontaneous Perforation of the Bladder Secondary to Osteomyelitis of the Pelvis A B Hepler and C F Eikenbary Am Jour Surg, October, 1933, XXII, 113-117

According to the authors, no mention of this condition can be found in a review of the literature. A few cases of perforation of the bladder by sequestra from non-tuberculous osteomyelitis have been reported, but the displacement of the bladder by a massive involucre as a constantly associated condition has not been considered. They feel that it is fairly frequent, judging from the fact that it was present in each of the four cases of osteomyelitis of the pelvis they have examined. The absence of signs and symptoms referable to the urinary tract accounts for the failure to consider this possible urinary complication. Even in the two cases with perforation, there were no subjective symptoms and examination was undertaken because of persistent pyuria.

The clinical significance of the condition lies, of course, in the possibility of perforation of the bladder, which occurred in two cases and might be assumed to be impending in the others, in which the engendering factors were the same. This should be an additional reason for early and thorough drainage of all suppurative processes in the hip joint or pelvic bones.

The operation for the osteovesical fistula is at times difficult because of the firm adhesions of the contiguous portion of the bladder to the involucre and the infiltration about the fistula, with danger of laceration. Healing is rapid and the operative results are good. Once corrected, the condition does not tend to recur, provided adequate drainage of the osteomyelitis is established.

DAVIS H PARDOLL, M.D

Experimental Ureteral Implantation Thomas J Kirwin. *Am Jour Surg*, January, 1934, XXIII, 14-29

While the present writer has reached the conclusion that intestinal implantation is an operation demanding greater technical skill and knowledge than are at the command of many surgeons working under ordinary conditions of practice, he is nevertheless convinced that the operation should be done whenever possible. Even if the remote results are unsatisfactory, the immediate relief afforded far outweighs the chance of later renal disease. To the question "Is the relief from the incontinence of ectopia vesicæ, the rapid fatality of vesical carcinoma, or the intolerable suffering endured in tuberculosis of the bladder, worth the possibility of destruction of one or both kidneys, or even eventual uremic death?" his answer would be an emphatic affirmative. Though it is only after much study and animal experimentation that a surgeon can be properly equipped to carry out this procedure, the number of men thus qualified is steadily increasing, though the operation must, of necessity, always be confined to the hands of a few specially selected and trained.

The thought he would leave in the minds of those who have followed this exposition is, that, despite the hazards which attend this operation, notwithstanding the unfortunate remote results which have been reported, and in spite of the many difficulties surrounding it, the implantation of the ureters into the large intestine is a most valuable procedure, and, properly performed, has given extended life, health, and happiness to many who would otherwise have suffered and died most miserably.

DAVIS H PARDOLL, M D

Ureteral Transplantation to the Rectosigmoid for Exstrophy of the Bladder, Complete Epispadias, and Other Urethral Abnormalities, with Total Urinary Incontinence. A Study of 85 Operative Cases. Waltman Walters and William F Braasch. *Am Jour Surg*, February, 1934, XXIII, 255-270

The treatment of exstrophy of the bladder and complete epispadias, with total urinary incontinence, is best carried out by transplantation of the ureters to the rectosigmoid. It has been equally well established for treatment of large vesicovaginal fistulas and of other lesions of the bladder and urethra that cause incontinence of urine, if plastic methods of closure can not be applied. In 85 cases of exstrophy of the bladder and total epispadias, with complete incontinence, encountered at the Mayo Clinic, the ureters have been transplanted to the rectosigmoid in separate stages without the use of tubes or catheters. The right ureter has been transplanted first, and the left, from 10 to 14 days later, if the patient's condition has permitted.

In a series of 25 cases in which Dr Walters operated one death occurred. A comparison of morbidity in hospital of the cases in which the ureters are transplanted one at a time, with that in the cases in which

the ureters are transplanted simultaneously, would indicate that there is very little difference. Intravenous urography in most of our recent cases has revealed that when the ureters are accurately transplanted by the Coffey submucous method, without use of catheters or tubes, little dilatation of the pelves calices, or ureters has occurred. The urine is held by a competent anal sphincter for an average of from two to four hours during the day and from three to five hours during the night. Plastic operations on the penis, restoring the contour to normal, are advisable and can be carried out at the time of cystectomy. The aseptic suture method of anastomosis, recently offered by Coffey, does not seem to us to be as useful as the method of submucous transplantation he first presented.

In a series of 42 cases of exstrophy of the bladder, operation was postponed or not recommended.

Intravenous urography and the usual methods of estimating renal function give valuable pre-operative information.

DAVIS H PARDOLL, M D

## GYNECOLOGY AND OBSTETRICS

Radiation Therapy of Tuberculosis of the Female Genital Organs. H Guthmann. *Strahlentherapie*, December, 1933, XLVIII, 776-789

The author uses small doses (4 to 12 per cent E D), at intervals of from 2 to 3 weeks, in the treatment of tuberculosis of the female genital organs. Of the 515 cases treated by irradiation, 85.9 per cent were either cured or markedly improved, while, on the other hand, 14.1 per cent were either not benefited or they died. The results obtained by operation alone were 64 per cent, and those treated by operation and irradiation were 88.1 per cent. In suitable cases, the combined treatment is, therefore, recommended.

ERNST A POHLE, M D, Ph D

Pregnancies after Salpingography. Günther K. F Schultze. *Röntgenpraxis*, September, 1933, V, 676-678

The roentgenologic examination of uterus and tubes by means of a contrast medium is not only a valuable diagnostic procedure, but also a therapeutic measure. The author reviews the findings in the cases seen in the Universitäts Frauenklinik in Berlin. Of 269 cases which could be followed, 115 showed bilateral occlusion of the tubes, 154 (57 per cent) patent tubes. Of these 154, 38 became pregnant after salpingography (25 per cent). If all patients in whom there might be any doubt about the causal connection between lipiodol injection and pregnancy are eliminated, there remains 13 per cent in whom unquestionably the pregnancy was a direct result of the salpingography. In most cases the woman became pregnant within twelve weeks after the examination. The mechanical dilatation of

the cervix, uterus, and tubes by the lipiodol injection, and possibly also a chemical irritation upon the mucosa, is the reason for the therapeutic effect

H W HEFKE, M D

## THE JOINTS

Thiemann's Epiphyseal Disease H Ryffel *Röntgenpraxis*, June, 1933, V, 423-432

Thiemann's epiphyseal disease is found in the epiphyses of the fingers, and sometimes of the toes, in young individuals during puberty. Roentgenologically the epiphyses are seen to be deformed, sometimes in the shape of a meniscus, the central portions are deformed and partially resorbed. The epiphyseal line may be irregular. The proximal interphalangeal joint of the third finger is most often attacked, but others may also show signs of the same disturbance, only the thumb has never been found involved. In three cases reported, the author demonstrated different stages of the disease. The correct diagnosis can be made only during the age of puberty. When the epiphyses disappear, the picture of an arthritis may be the only sign of the disturbance. In one case the disease was so severe that the patient had to change his occupation, yet in many it runs its course unrecognized, because it does not cause any symptoms. In slight cases a perfect healing takes place, while in more marked cases the basis of the diaphyses remains deformed and widened. This disturbance is combined with a hypofunction of the sexual glands in all of the author's cases, and an increase in the size of the hypophysis speaks also for disturbances of the internal secretions. The three patients are children of the same parents, and it appears probable that other adults in the same family also had this disease, which, therefore, seems hereditary.

H W HEFKE, M D

Arthropneumoradiography in Habitual Luxation of the Shoulder J Oberholzer *Röntgenpraxis*, August, 1933, V, 589, 590

In questionable injuries and diseases of the knee joint, 700 arthropneumoradiographies have been done in the hospital from which this article is published. Other joints—for instance, the shoulder joint—have been examined by this method also, but it is more difficult and the results are as yet not entirely satisfactory. The puncture is made between the coracoid process and the tuberculum minus of the humerus. Only oxygen has been injected, not a combination of skiodan and oxygen as in the knee joint. A case is described in which this method showed nicely the exact localization of the defect of the capsule, and surgical exploration proved the correctness of the radiologic diagnosis. That the method is harmless, if done correctly, is proven by the experience in 700 cases of arthropneumoradiography of the knee joint.

H W HEFKE, M D

Roentgen Examination of the Shoulder Joint. H Jordan-Narath *Röntgenpraxis*, September, 1933, V, 686-688

While roentgenograms of the extremities are always done in two planes, the shoulder joint and the surrounding bones are an exception in most instances, one is usually satisfied with the antero-posterior film. Yet the examination of the shoulder in one direction only is just as unsatisfactory as in the case of the extremities—some fracture might be shown only in the axial roentgenogram. It is easy to get it when one has a shock-proof apparatus. The x-ray tube is under the shoulder, the film in an adjustable stand above the shoulder, and the direction of the rays is from below to above the shoulder. This method is well worth while in the opinion of the author, and should be used in all cases of disease or injury of the shoulder.

H W HEFKE, M D

A Contribution to the Hypertrophic Ossidesmosis Václav Sváb *Röntgenpraxis*, June, 1933, V, 437-440

According to Kienboeck and Selka, hypertrophic ossidesmosis is an ossification of many ligaments of the body (ligaments of the spine, pelvis, etc.). The author observed such a case and describes it in detail. Some of the lumbar vertebrae were connected by thick bony masses, the left ligamentum sacrotuberosum, which leads from the sacrum to the tuberosity of the os ischium, was ossified in its entirety. The hip joints showed evidence of hypertrophic changes. The etiology of this disease is not clear.

H W HEFKE, M D

## THE KIDNEYS

Congenital Pelvic Kidney B M Palmer *Am Jour Surg*, November, 1933, XXII, 220-222

This paper presents a case of congenital pelvic kidney containing a stone, and a brief review of the literature. The different forms of operative approach are discussed. A pyelogram should be done in any case of unexplained unilateral pain to rule out anomalies of the urinary tract. The case reported well illustrates the advisability of pre-operative pyelo ureterograms in all cases in which a stone is thought to be included in the pelvis of a kidney in the ureter.

DAVIS H PARDOLL, M D

Renal Infarcts Clarence C Saellhof *Am Jour Surg*, November, 1933, XXII, 227, 228

A case of renal infarction is reported. At operation, the true pathologic alteration of renal infarction was observed on gross and microscopic sections. Autopsy revealed multiple thrombi of heart and lungs with terminal infarct formation.

DAVIS H PARDOLL, M D

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or three-quarter views and a lateral view of the fifth lumbar and upper sacral vertebræ. The former show the joint space between the articular facets clearly. The combined evidence of the above-mentioned rays presents all evidence necessary in the diagnosis of facet involvement. Treatment is conservative in the majority, in a limited group, for economic and other reasons, surgery is indicated.

C G SUTHERLAND, M D

Meningocele Simulating an Intrathoracic Tumor  
R Pohl *Röntgenpraxis*, October, 1933, V, 747-749

The roentgenologic differentiation of round shadows in the thorax is often difficult inasmuch as they may have their origin from the lung, pleura, the large vessels, or the thoracic wall. An unusual case is described in which there was a large round, well circumscribed shadow in the right chest and also a marked scoliosis of the thoracic spine. The tumor was thought to be a neurofibroma. At operation a meningocele the size of a fist was found which came from the fourth dorsal vertebra. Too little attention had been paid to the deformity of the dorsal spine. A similar case could not be found in the literature.

H W HEFKE, M D

## THE STOMACH

Syphilis of the Stomach, with Special Reference to its Recognition at Operation. K A Meyer and H A Singer. *Arch Surg*, March, 1933, XXVI, 443-464.

From a surgical standpoint, the distinguishing features between syphilis of the stomach and carcinoma are as follows. There is a striking disparity in many cases between the extent of the lesion as determined roentgenologically and the extent as observed operatively by palpation. In carcinoma, one generally finds at laparotomy a more extensive involvement than the x-ray film indicates. In syphilis of the stomach, there is a surprising paucity or complete absence of changes as determined by palpation. The common lesion of gastric syphilis is not a spherical prominence as in a tumor, gummatous or neoplastic, but is a flat infiltrate that leads to a plaque-like thickening of the gastric wall. When thin, the infiltrate is readily overlooked. When thick, its relatively soft consistency and pliability distinguish it from carcinoma. Inspection of the interior of the stomach generally discloses one or more superficial, serpiginous ulcers involving a large part of the plateau formed by the infiltrate.

HOWARD P DOUB, M D

## THE THORAX

Tuberculosis of the Azygos Lobe of the Lung  
Giacomo Bagnaresi. *Archivio di Radiologia*, 1933, XI, No 4, pp 697-708

The author reports three cases of right-sided azygos lobe. In two of them there were clinical and radiologic signs suggestive of a pleuritis of the fissure of the azygos lobe. He emphasizes the difficulty of diagnosing tuberculosis of the azygos lobe and the rarity of this lesion.

E T LEDDY, M D

Two Unusual Cases of Polylymphglandular Calcification. Giovanni Moschetta. *Archivio di Radiologia*, 1933, XI, No 4, pp 682-696

The author, after reviewing two cases of extensive calcification of the lymph nodes of the neck, points out the importance the cervical lymph nodes may have in demonstrating a cervico apical origin of pulmonary tuberculosis.

E T LEDDY, M D

Post-traumatic Calcifications of the Pleura. Luigi Ferretti. *Archivio di Radiologia*, 1933, XII, Nos 5 and 6, pp 959-969

This is a radiologic and clinical review of one case of calcification in the pleura, as a result of war wounds.

E T LEDDY, M D

A Contribution to the Diagnosis and Treatment of Actinomycosis. Andreas Gaál. *Röntgenpraxis*, September, 1933, V, 650-653

A 37-year-old farmer was examined one week after the beginning of his sickness, which was diagnosed as a pneumonia with possible abscess formation. An x-ray examination showed two well-circumscribed shadows in the right lung, which showed no inflammatory reaction around them. They looked like metastases or echinococcal cysts. Sputum examination showed the presence of actinomycotic fungi. Irradiation of the diseased lung was undertaken (daily, about 150 r per field). Even with this small dose, the reaction was very marked and the patient expectorated large amounts of bloody and foul-smelling sputum. A week afterward (three x-ray treatments) the areas in the right lung were much less dense, but there was a new area of infiltration in the left lung. Repeated irradiation achieved complete clinical recovery and disappearance of the lung infiltrations. Beside roentgenotherapy, Pot iodide and Mang chlor were given internally.

H W HEFKE, M D

Interpretation of Chest Roentgenograms. Kennon Dunham. *Jour Am Med Assn*, Dec 9, 1933, CI, 1857-1859

Many years of study of necropsy material to determine the relation between x-ray densities and pathologic observations has demonstrated that the relative degrees of scar tissue and pulmonary exudate can be determined from a study of x-ray films with sufficient accuracy to be of great practical value in the diagnosis,



## THE LARYNX

The Roentgen Treatment of Papillomatosis of the Larynx L Popp *Röntgenpraxis*, October, 1933, V, 739, 740

Papillomatosis of the larynx is seen much more frequently in children than in adults. It is believed that these papillomas are not newgrowths but areas of inflammatory proliferation. Clinically, papillomas of the larynx are characterized by increasing hoarseness and possibly a laryngeal stenosis. Operative treatment unfortunately does not often effect a cure, recurrences are frequent and dissemination by implantation during operation is possible. The opinion of the author is divided as far as the value of irradiation is concerned. He has treated two such cases (a 30-year-old woman and an 8-year-old child) that were cured by x-ray therapy and remained so for one and one-half and two years, respectively. In children, roentgentherapy is the treatment of choice, in adults, surgical removal followed by roentgentherapy seems to be the more logical treatment.

H W HEFKE, M D

## LIPS AND JAWS

Carcinoma of the Lip Suggestions for its Treatment R Stewart-Harrison *Röntgenpraxis*, August, 1933, V, 583-586

The treatment of carcinoma of the lip has changed—surgical treatment is abandoned and the radiotherapeutic method is preferred. From the Roentgen Institute of the University of Zürich (Prof Schinz), the author quotes statistics and finds that irradiation of the primary tumor in the lip must to-day be the method of choice. When roentgen rays are used in small tumors 1,500 r in a single dose must be given. Radium, however (especially in molds), is used in the greater number of cases (Regaud's technic)—when the tumor's infiltration is very extensive, radium implantation is preferable. If neighboring structures have been attacked, radium cannot be used, but protracted fractionated roentgen irradiation (about 6,000 r measured in air given in about twenty days) is indicated, sometimes in combination with electrocoagulation. The treatment of the cervical glands is still open to discussion. In Zürich, surgery plus roentgentherapy has been proven satisfactory in most instances. If there is no involvement of the glands demonstrable, surgery is postponed and the patient is carefully watched. Only if there appears to be a good chance of cure of the primary tumor, may the glands be removed surgically and the neck be irradiated if these glands were metastatic.

H W HEFKE, M D

## THE SPINE

Semi-vertebræ as a Cause for Congenital Kyphoses Herbert Junghanns *Röntgenpraxis*, August, 1933, V, 561-563

Wedge shaped semi-vertebræ are most often responsible for congenital scolioses. Often one deals with supernumerary semi-vertebræ, which are primarily rectangular, but become wedge shaped by static pressure. Much more rare are anomalies of a similar nature which cause kyphosis, only about fifteen instances having been described in the literature. The author of the present paper reports two cases.

In a lateral roentgenogram of the spine of a 15-year-old boy, the first lumbar vertebra has been developed only in its posterior half, its shape is rectangular, and there is only a slight degree of kyphosis. The patient showed also symptoms of a chondodystrophy (very low vertebral bodies and very short phalanges). The second case is that of a 45-year-old man in whom the second lumbar vertebra is only half as long in the ventrodorsal axis as the normal vertebra, the anomalous vertebra is wedge shaped. There is a marked kyphosis and the anterior edges of the first and third lumbar vertebrae are in direct contact—both show marked hypertrophic spurs. This second case can be considered as the final stage of the anomaly first described in the case of the 15-year-old boy. The history showed that this kyphosis had developed slowly.

H W HEFKE, M D

Some Lacunar Formations Seen Radiographically in the Vertebral Bodies Desiderio Perotti *Arch di Radiologia*, 1933, XI, Fasc 3, pp 552-559

The author describes and illustrates some lacunar and fissural appearances radiologically visible in the vertebral bodies of adults with spondylitis, with some of the other osteo-arthropathies, with rickets, and with no disease. Perotti is inclined to regard them as vascular lacunæ.

E T LEDDA, M.D

Low Back Pain, with Special Reference to Articular Facets, with Presentation of Operative Procedure Ralph K Ghormley *Jour Am Med Assn*, Dec 2, 1933, CI, 1773-1777

Study of the vertebrae and particularly their articular facets makes obvious the importance of the latter in the function of the spinal column. The articular facets must be regarded as the only true joints in the spinal column. Many of the aches and pains which are known as "backache" are true pains of the joints. The degenerative changes that are characteristically seen in hyaline cartilage may be seen in the articular cartilage of these facets, together with the eburnation of the underlying bony trabeculae. This degeneration may go on to complete loss of the cartilaginous surface, and irregular hypertrophy of the margins, similar to that seen in the advanced stages of degeneration or hypertrophic arthritis of other joints. The facets are not only causes of sciatic pain, but they may be causes of lumbosacral pain with or without sciatic pain. Roentgenologic evidence is obtainable only by oblique

examination was essentially negative except for the legs, which presented the appearance of polyneuritis. There was a leukocytosis of 22,000. Chest films taken on admission were negative but when re-examined six weeks later, with the physical findings remaining practically negative, there was seen diffuse perivascular infiltration spreading out equally and uniformly from both hilar regions, with the involvement being rather sharply limited about midway in each lung field (this appearance being consistent with the characteristic pathologic limitation to vessels of a given, usually moderate, size). Further x-ray films, taken a few days thereafter, showed more peribronchial or vascular exudation. The patient died about two months later, at which time the changes in the left lung had cleared in part, while in the right chest a pleural effusion had developed. Necropsy showed multiple and diffuse nodosities of periarteritis involving the blood vessels of the kidneys, heart, and lungs. Both the pulmonary and bronchial artery branches were involved. The lungs showed multiple hemorrhagic infarcts.

J E HABBE, M D

The Normal and Pathologic Azygos Lobe Bottaliga Mario *Archivio di Radiologia*, 1933, XII, Nos 5 and 6, pp 1082-1090

This is a discussion of three cases of azygos lobe encountered in 1,500 radiographs, one with autopsy control, one in which the position of the lobe varied with the position of the patient, and one of interlobar pleuritis checked up two years later and found to have no detectable residual lesion.

E T LEDDI, M D

## TUMORS (THERAPY)

Radiosensitivity of Tumors Fred W Stewart *Arch Surg*, December, 1933, XXVII, 979-1064

This is a long and extremely valuable monograph which it is impossible to abstract in detail as the author covers practically all tumors and it should be in the files of every radiologist for constant reference. In this abstract we will refer only to some of the general conclusions drawn by the author.

Opinions as to radiosensitivity of tumors are entirely different to day, with the modern methods of radiation therapy from what they were in the low voltage x-ray period. Radiosensitivity may mean rapid tumor regression, low progressive regression, or slow chronic atrophy, requiring months or perhaps a year for completion. Radiosensitivity does not mean the certainty of cure by irradiation nor does radioresistance imply that a given tumor is not curable by irradiation, as certain tumors seem to possess inherent properties of radioresistance, for example, melanomas and neurogenic tumors.

Radiosensitivity increases with increasing embryonal qualities of the tumor cell although not all tumors of

embryonal origin are equally radiosensitive. Radiosensitivity increases with the increasing degree of anaplasia, although not all anaplastic tumors are radiosensitive. Radiosensitivity is always a relative property. When one states that a carcinoma of the breast, for example, is radiosensitive, one should imply that it is sensitive according to the accustomed scale of behavior of tumors of the breast and not according to the same scale of sensitivity one applies to lymphosarcoma.

Tumors are apt to be more sensitive in young subjects. Infection interferes with the normal response to radiation. Desmoplastic tumors are apt to be radioresistant. The tumor bed is of great importance. Bone cartilage and fat make unfavorable media for reactive processes and, hence, for regression of the tumor. An avascular bed is unfavorable for response to radiation. Tumors, when metastatic to lymph nodes, may be more or less sensitive than the primary tumor. Bulky tumors may become resistant after infarction and liquefaction, even though they belong to usually sensitive types. Anatomic characteristics are of decided importance. Among these may be mentioned the papillary character, delicacy of the blood supply, and inclosure within a firm capsule which may result in the obliteration of circulation after irradiation has caused the tumor to become edematous.

The effect of radiation is always complex. It involves not only the tumor cells, but the tissues of the host and possibly general reaction on the part of the host. The ultimate effect of irradiation must always result from a nice balance between tumor effect and response of the tissue host.

HOWARD P DOUB, M D

Radiotherapy as a Method of Identifying Certain Varieties of Tumor Arthur U Desjardins *Jour Am Med Assn*, Nov 25, 1933, CI, 1705-1710

Microscopic examination, until now, has been the only method by which substantial accuracy in the identification of neoplasms can be achieved. Great as is the ability of the really competent pathologist cases are occasionally encountered in which his interpretation proves to have been erroneous. The most experienced pathologists frankly admit that they are often puzzled and uncertain. The radiotherapeutic method is based on the well-established fact that each variety of cell in the body has a specific sensitiveness or, rather, a specific range of sensitiveness to roentgen rays or radium. A certain measure of variation in reaction must occur. However, if allowance is made for such variation, and if reaction time is taken as a criterion, the specific sensitiveness of each kind of cell looms up as a dominant single fact of radiology and deserves to be recognized as a law. According to present knowledge, cells may be classified, according to their radiosensitivity, in the following order: Lymphoid cells (lymphocytes), polymorphonuclear and eosinophilic leukocytes, epithelial cells (1) basal

prognosis, and treatment of pulmonary tuberculosis. The study of a case of pulmonary tuberculosis necessitates the determination of not only the extent and location of the lesions but also the relative amounts of scar tissue (repair, suggesting resistance) and of the pulmonary exudate (acute inflammation). Pulmonary tuberculosis may manifest itself as lobar pneumonia, lobular pneumonia, or bronchopneumonia. Adult apical and subapical tuberculosis starts as a lobular pneumonia and most commonly develops in the posterior apical bronchus, first visualized as a fan in the x-ray plate. Caseous bronchopneumonia usually follows when the lobular pneumonias break down and liberate nascent tubercle bacilli.

Tuberculous lobar pneumonia is not as prevalent as tuberculous lobular pneumonia but is a common lesion. It has been written of as basal tuberculosis. Lobular tuberculosis, a localized inflammation, more frequently repairs and lays down scar tissue and is often spoken of as fibroid tuberculosis. It is all-important to distinguish between scar tissue and pulmonary exudate. If the exudate is spreading, one may expect that an abscess will develop and a cavity form. If the exudate is not spreading, one may expect that scar tissue is being laid down and that absorption is taking place.

C. G. SUTHERLAND, M.D.

Some Consideration of the End stages of Pneumothorax as Seen Radiologically. V. Podesta. *Arch di Radiologia*, 1933, XI, Fasc. 3, pp. 529-551.

As exemplified by 10 cases, Podesta points out some of the criteria and pitfalls to be considered in the roentgenologic study of pneumothorax.

E. T. LEDDY, M.D.

A Pathologic, Anatomic, and Radiologic Study of the Vena Azygos Lobe and the Cardiac Lobe of the Lung. G. Vita. *Archivio di Radiologia*, 1933, XII, Nos. 5 and 6, pp. 921-941.

The author had occasion to study radiologically and with autopsy control a case having an azygos and a cardiac lobe of the right lung. The patient died from military tuberculosis, which in the accessory lobes presented nothing different from what it did in the other lobes. Injection of an opaque medium showed that the azygos lobe had its bronchus markedly linked at its origin—a fact which may explain the frequency with which these lobes are found to be atelectatic.

E. T. LEDDY, M.D.

Pleural and Pulmonary Calcifications. Rudolf Pohl. *Röntgenpraxis*, September, 1933, V, 641-649.

Calcifications in pleura and lungs are seen in numerous cases, their demonstration during life being possible only by means of the roentgen ray. Pleural calcifications cannot always be seen fluoroscopically—often a

film is necessary. The deposition of calcium takes place almost always in scar tissue, sometimes in nodular form, sometimes in plaques. Usually a pleuritic exudate or an empyema has preceded the calcification. Unquestionably one of the main etiologic factors for it is a hemothorax, following a trauma. These calcifications are most often situated in the basal portions of the lungs, sometimes in the apex, while they are comparatively rare in the interlobar pleura. Calcification in the lung is most often seen as Ghon's primary complex. Intrapulmonary myomas and fibromas may show central deposition of calcium. Chondromas almost regularly show large areas of calcification. Echinococcal cysts may contain lime in their walls. Small areas of calcification may be caused by bronchioliths, the roentgen diagnosis of which is almost impossible. Disseminated calcified areas are seen often in the healed stage of chronic disseminated tuberculosis of the lungs. Calcification in old infarcts has been reported. Linear net-like calcification of the lungs has been reported (*pneumopathia osteoplastica racemosa*) in the case of old persons and at the periphery of the lungs (two cases are reported). Chronic inflammatory changes are probably an etiologic factor.

H. W. HEFKE, M.D.

The Roentgenologic Appearance of Polycythemia Vera. Also a Contribution to the Roentgenologic Demonstration of Passive Congestion of the Lungs. Brednow. *Röntgenpraxis*, October, 1933, V, 732-738.

The normal lung markings are due to the shadows of blood vessels, mostly arteries. It is evident that in the cases of polycythemia vera, in which there is considerable increase in the circulating amount of blood, there must be a widening of the lung vessels also.

Three cases are reported. The characteristic roentgen appearance is the much emphasized, sharp reproduction of the blood vessels in both lungs—the ramification of the vessels can be followed into the periphery. Roentgenograms of passive congestion of the lungs are typified not only by an increase in the lung vessel shadows, but also by lack of sharpness in the hilar region. In one case with polycythemia and cardiac failure, the typical picture of a pure polycythemia remained after the passive congestion of the lung disappeared.

H. W. HEFKE, M.D.

Pulmonary Changes in a Case of Periarteritis Nodosa. W. G. Herrman. *Am Jour Roentgenol and Rad Ther*, May, 1933, XXIX, 607-611.

In the author's case, a woman, aged 40, entered the hospital complaining of pain in the left shoulder, hacking cough, night sweats, loss of weight, and afternoon temperature. Several weeks after onset of these symptoms, there was numbness in the feet and loss of motor function in the lower extremities. Physical

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epithelium of certain secretory glands, especially of the salivary glands, (2) basal epithelium (spermatogonial cells) of the testes and follicular epithelium of the ovary, (3) basal epithelium of the skin, mucous membranes, and certain organs, such as the stomach and small intestine, (4) alveolar epithelium of the lungs and epithelium of the bile ducts (liver), and (5) epithelium of tubules of the kidneys, endothelial cells of blood vessels, pleura, and peritoneum, connective tissue cells, muscle cells, bone cells, nerve cells. The difference in susceptibility between lymphoid and epithelial cells is sufficient to enable one to distinguish readily between the two.

Five specific cases are reviewed to illustrate the points of the essay.

C G SUTHERLAND, M D

The Fate of Fibromyoma of the Uterus after Radiotherapy. James A. Corcoran. *Am Jour Roentgenol and Rad Ther*, April, 1933, XXIX, 511-515.

In a series of 452 women treated by x-rays or radium for bleeding and fibroids, there were 130 with a uterus larger than that of a three months' gestation, of which latter group 112 have had follow-up studies. Following diagnostic curettage, the cases earlier treated were given x-rays only, while the later ones had from 600 to 4,800 mg-lir of radium filtered by 0.5 mm silver to 1.0 mm platinum. With tumors larger than a six months' pregnancy, radiotherapy may control the bleeding and in patients who are poor operative risks at the time it may be definitely indicated, although surgical treatment is more satisfactory when it can be safely done. There were no serious tumor changes (sarcoma, degeneration) in this group of 112 cases, followed for an average period of seven years. Following radiotherapy in sterilizing dose, there was satisfactory shrinkage of the tumor in 90 per cent of the cases. When the cervical canal is long and tortuous, radium may be replaced by roentgen rays and the desired purpose accomplished. Roentgen therapy is safer than radium in the presence of old pelvic inflammatory disease.

J E HADDE, M D

Report about the Results of Irradiation of Malignant Tumors in the Year 1932. H. R. Schinz, A. Zuppinger, and R. Stewart-Harrison. *Röntgenpraxis* June, 1933, V, 401-410.

As in 1930, also in 1931, the results of irradiation therapy in the Roentgen Institute of the University of

Zürich are reported. Based on their own results and on comparative studies of the literature, the authors consider the indications for irradiation therapy. In the large majority of carcinomas of the skin, lip, penis, and cervix uteri (both in the operable and inoperable stage), irradiation is the method of choice, also in lymphatic sarcomas, round-cell sarcomas, myelomas, Ewing sarcomas, some ovarian and testicular tumors, and all tumors of the pharynx and larynx. Exclusively surgical are all operable adenocarcinomas (stomach, colon, rectum, kidney, bladder, prostate, and uterus). Irradiation therapy of these tumors, unless they are inoperable, is at present contra-indicated. A combination of surgery and irradiation is used in carcinomas of the mouth and thyroid. In cancer of the breast, Stage I, without glandular involvement, operation without post-operative irradiation is the method of choice, while pre-operative irradiation is indicated in the other stages. In many cancer cases only palliation can be achieved by irradiation.

Of great importance is the fact that the Roentgen Institute has its own hospital department of 30 beds, that is necessary because an intensive radiotherapeutic treatment of a cancer patient is equal to a rather severe surgical procedure and the radiologist should observe and treat his patient daily as much as the surgeon.

From the tables reproduced in this article it appears that from 19 to 28 per cent of all new cases could be made symptom free at least temporarily, and in another 35 per cent local cure and palliation could be achieved. Altogether, in from 56 to 63 per cent of the patients some beneficial results can be reported. Protracted fractionated and fractionated irradiation were used in the largest percentage of cases. Diagnostic biopsy and co-operation with the surgeon are of much value. Follow-ups of the patients and reliable statistics about three- or five-year cures are hard to get. Results in cases of carcinoma of the lip, larynx, and pharynx are evaluated for longer periods of time.

H W HEFKE, M D

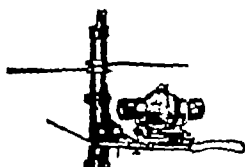
The Evaluation of Irradiation in Papillary Ovarian Tumors. Stefan Simon. *Strahlentherapie*, 1933, XLVI, 444-468.

The author describes in detail six cases with ovarian tumors subjected to radiation therapy. Photomicrographs of each growth are shown. Since but little information on this type of malignancy can be found in the literature the article is recommended for study in the original.

ERNST A. POHLE, M D, Ph D

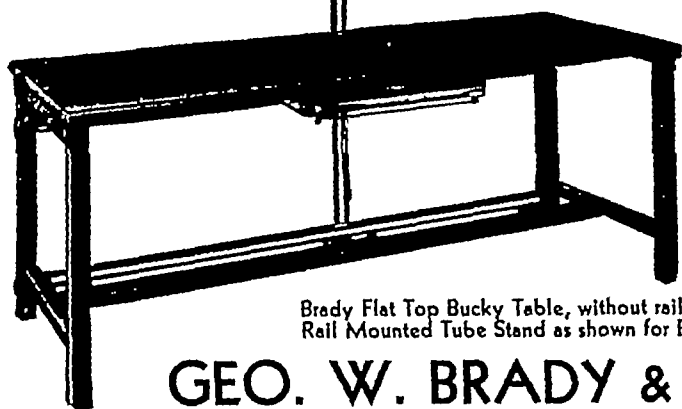
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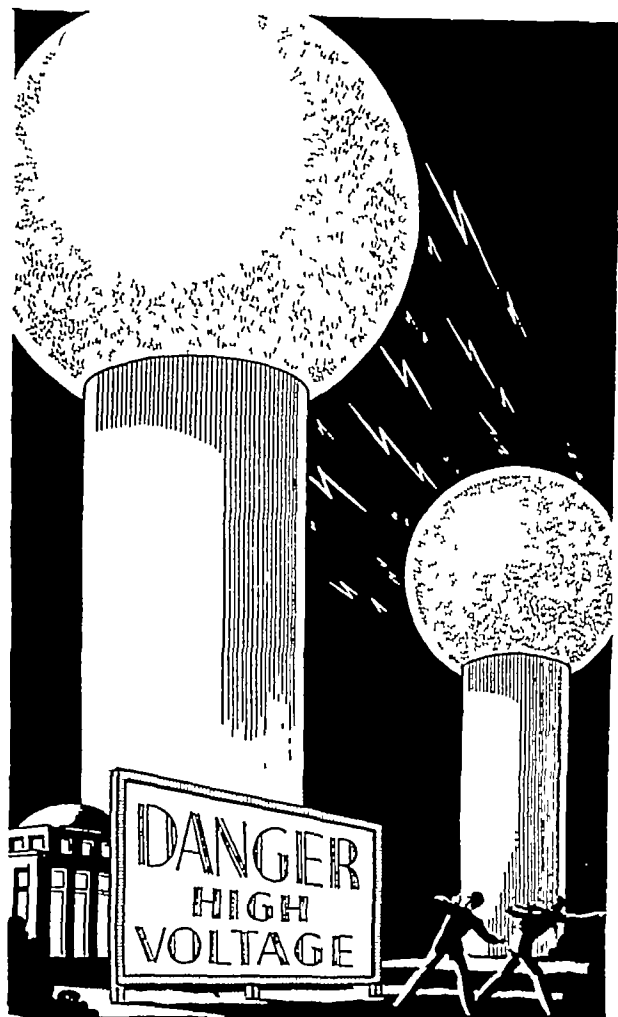
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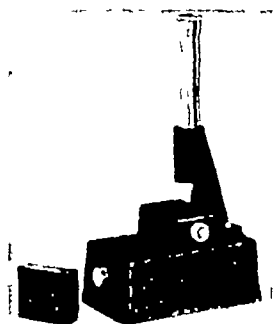
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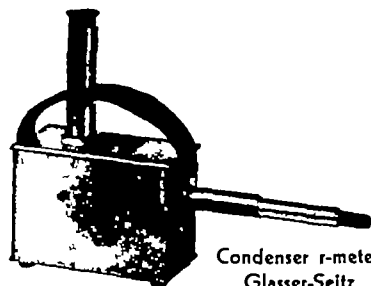
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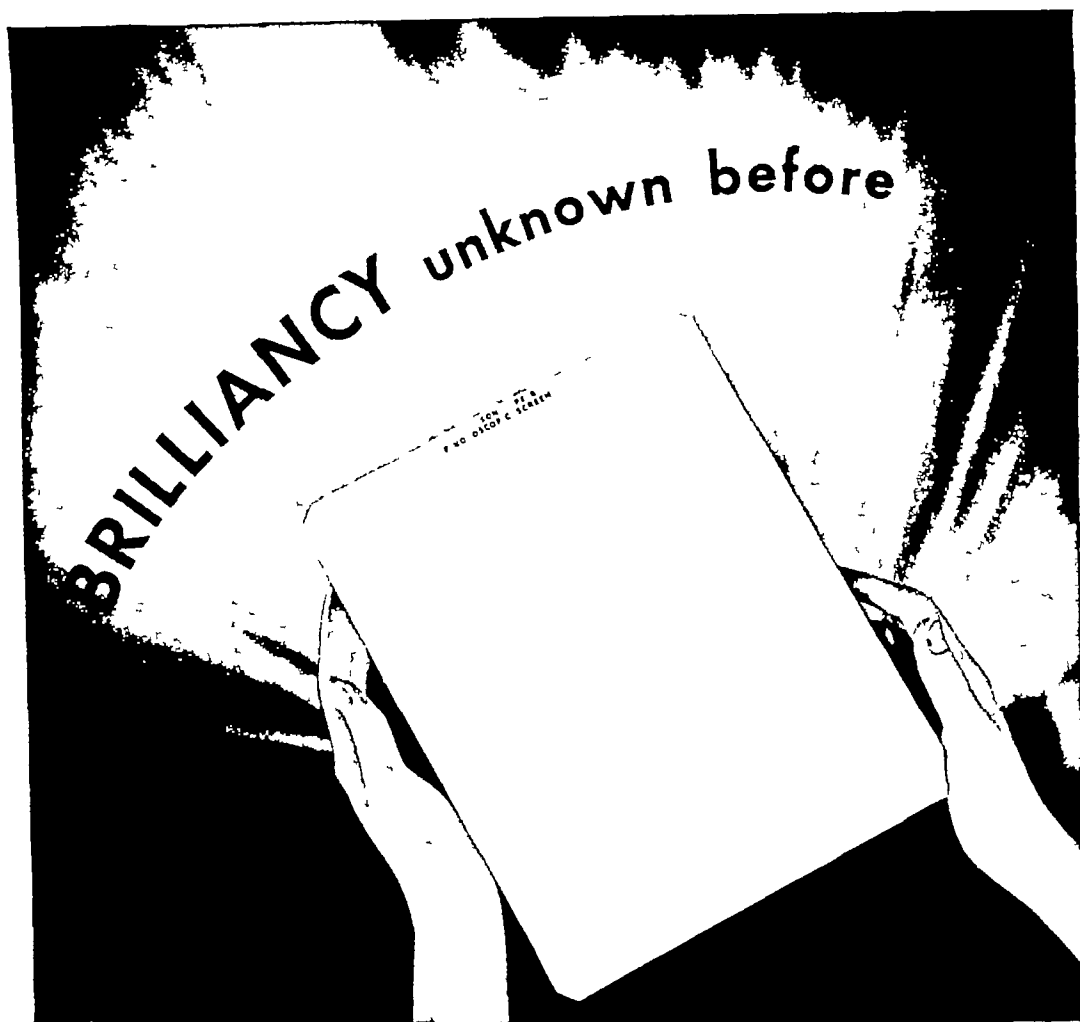
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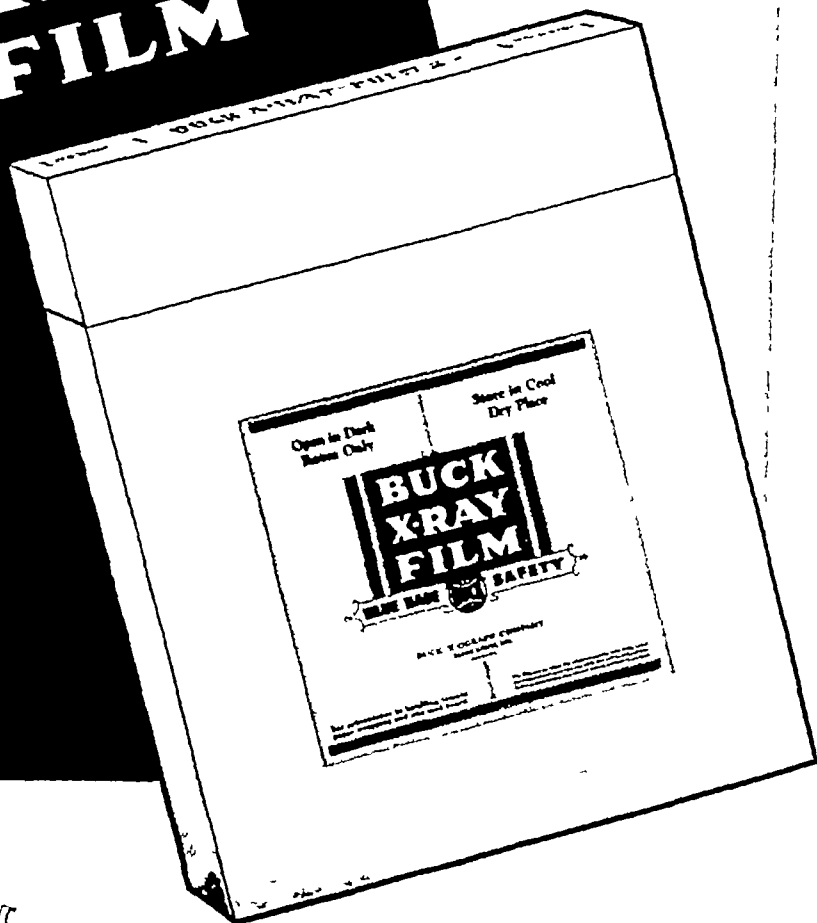
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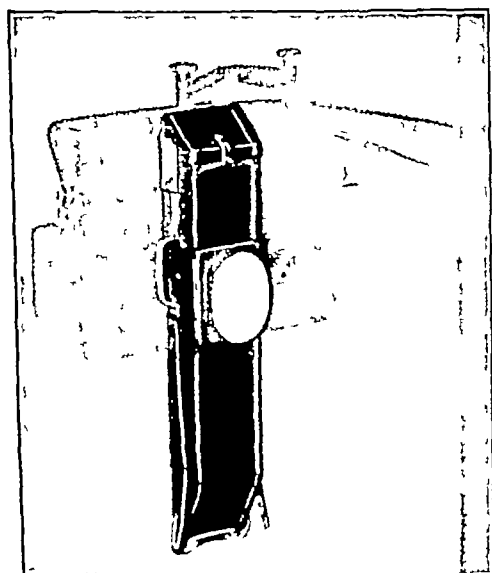
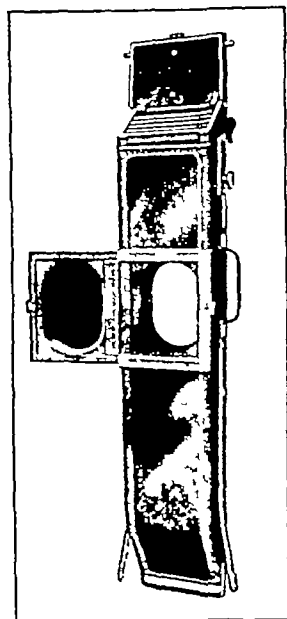
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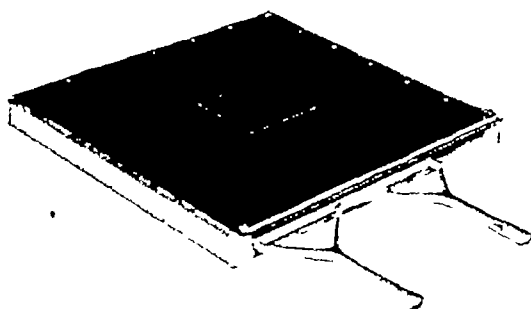
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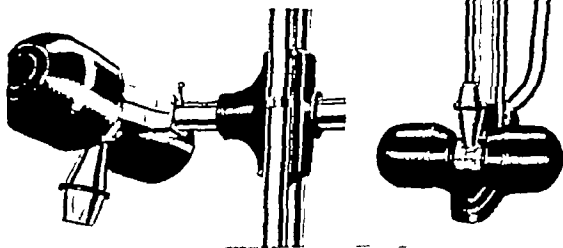
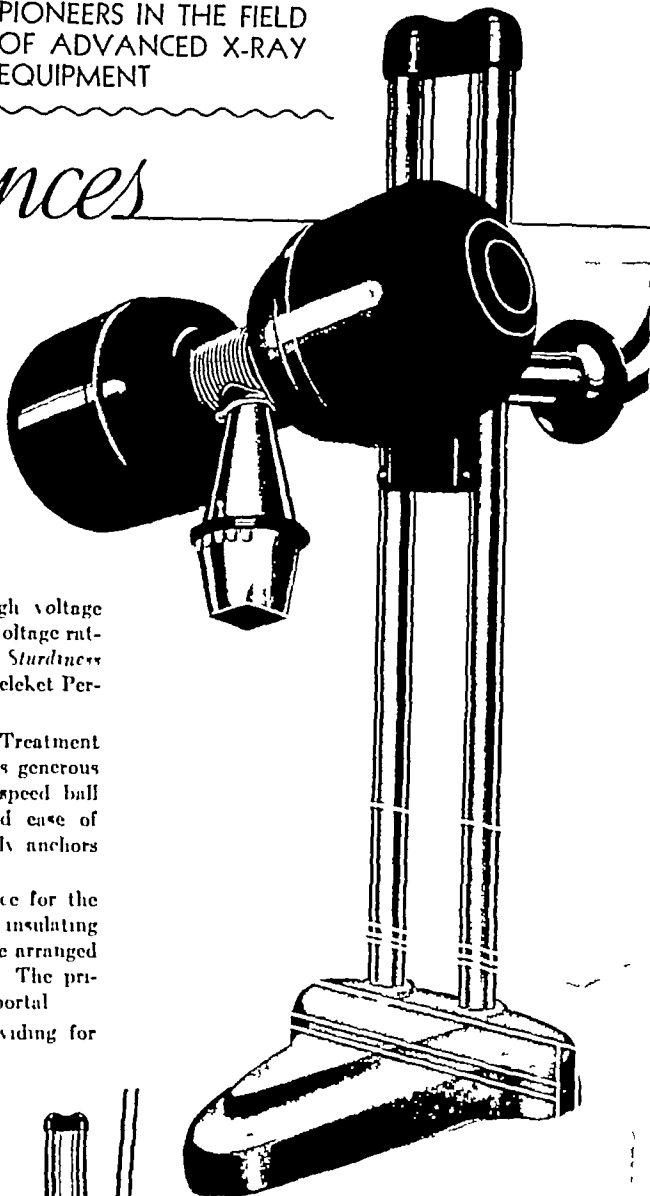
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CASES of bone tumors usually offer only an unfavorable prognosis unless they are detected in their earliest stages. For they metastasize rapidly and ultimately produce fatal conditions. Each type of bone tumor, whether benign or malignant, requires its own particular measures of treatment and accompanying precautions. But in every case the most important single element in the therapeutic

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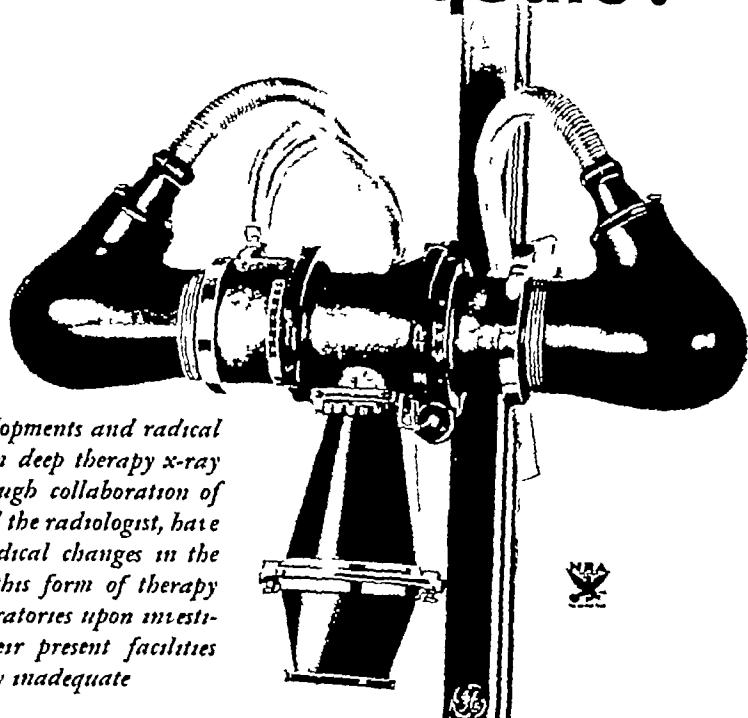
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VOL. XX

NOV. 1931

NO. 4

## OSTEOLYTIC BONE TUMORS\*

By LEOPOLD JACHES, M.D., and MARCY L. SUSSMAN, M.D., The Mount Sinai Hospital

From the Department of Radiology, The Mount Sinai Hospital, New York City

HERE has been an increasing interest in recent years in the subject of the diagnosis of bone tumors. Due largely to the outstanding contributions of American investigators. Because of this however, there has also arisen a tendency to regard the subject as having arrived at the stage of ease and accuracy. Certainly, all experienced radiologists are familiar with the typical lesions occurring at the usual age, the usual site, and having the usual appearance. It is our impression, however, that in any individual case, these normal criteria may be of no use and that even the differentiation between benign and malignant may not be possible. It is proposed to show some of the more unusual cases of osteolytic bone tumors that have come under our observation, and to discuss the roentgen findings in these groups.

### 1. Classification of Osteolytic Bone Tumors.

Cystic disease  
Giant-cell tumor  
Angioma  
Chondroma  
Osteogenic sarcoma; liposarcoma  
Ewing's endotheliomyeloma  
Multiple myeloma; solitary and diffuse;

Metastatic malignancy; solitary and diffuse

### A. Involvement in a systemic disease:

Xanthomatosis  
Lymphogranuloma  
Leukemia and certain anemias

### B. Differential diagnosis from:

Cystic tuberculosis  
Fibrocystic disease and rarefying osteomyelitis in syphilis  
Bone changes in leprosy and Raynaud's disease  
Bone changes in sarcoid and related lesions  
Brodie's abscess and metastatic osteomyelitis  
Parasitic diseases

*Cystic Disease.*—There are four clinical types of cystic tumors of bone:

1. The *solitary bone cyst* in patients aged from 5 to 15, usually found following a trauma.

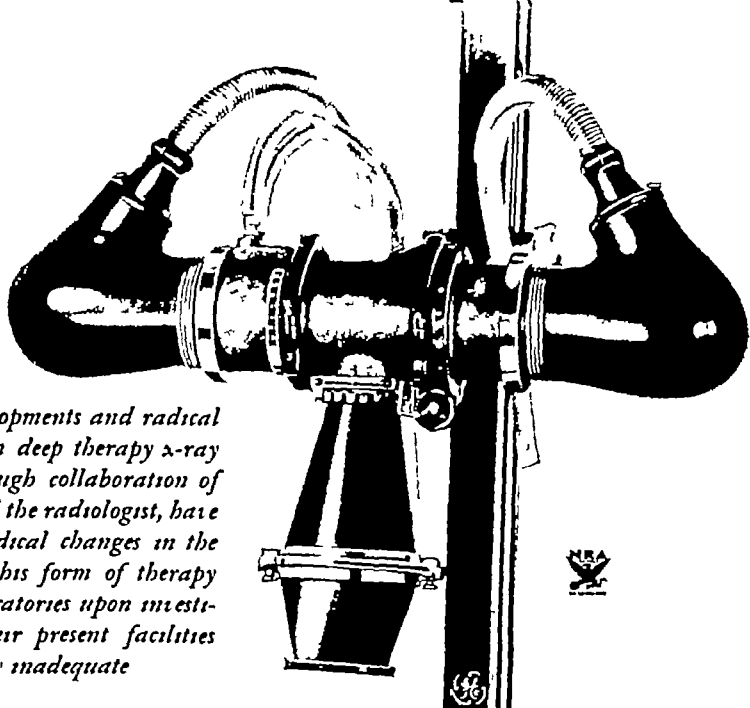
2. *Acute bone cyst* bordering directly on the epiphyseal line on the metaphyseal side, containing giant-cell areas histologically. Some authors refer to this type as giant-cell tumors and suggest that most bone cysts are "burned-out" giant-cell tumors. Such cysts often roentgenologically have the typical appearance of the latter tumors and are indistinguishable from them.

\*Read at the Eighteenth Annual Meeting of the Radiological Society of North America, at Atlantic City, Nov. 28-Dec. 1, 1931.

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minuted fracture, nor in bone atrophy from disuse

*Giant-cell Tumor*—Roentgenologically, as Kirklin and Claude Moore (7), as well as Peirce (9), have so ably pointed out of late,

portion of the bone, the lysis extending toward the cortex so that either a thin shell of bone remains or none at all

The present case (Fig 1) is a female of 26 who noticed a gradually increasing swelling



Figs 2-A and 2-B Male, aged 16 Pathologic diagnosis Osteolytic sarcoma 2-A, taken May 9, 1931 2-B, taken Sept 8 1931 after deep roentgen therapy

the giant-cell tumors fall roughly into two groups

1 An asymmetrical bone destruction in an epiphysis in the adult, or juxta-epiphyseal in a child, beginning subcortically and extending centrally The expanded bone shell is extremely thin and is often soon perforated The tumor may be trabeculated early There is no periosteal reaction

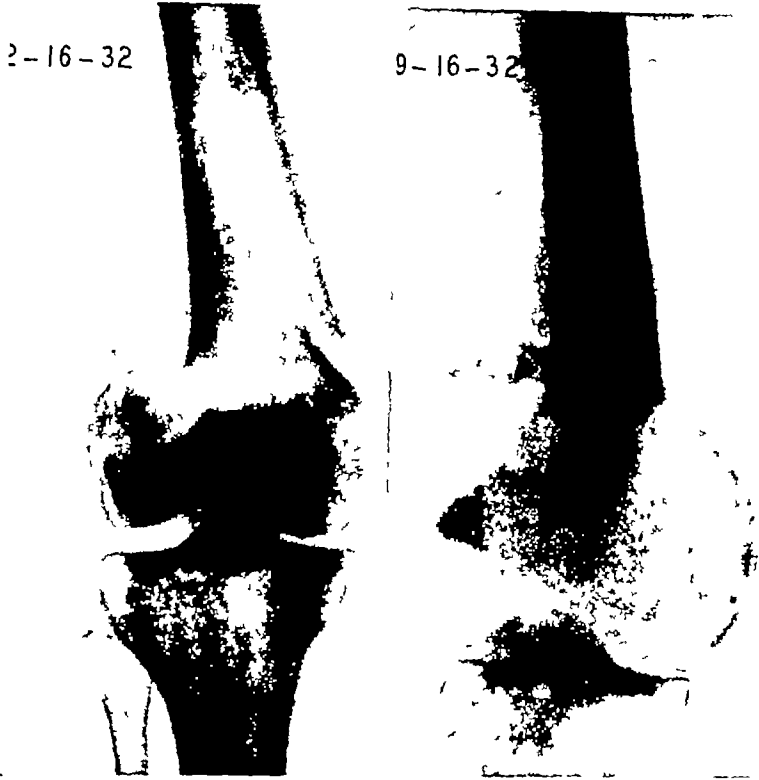
2 Homogeneous lysis of the central

around the left knee about three months before this first examination She suffered a slight trauma three weeks later but roentgen examination made elsewhere showed no bony changes There was some fullness in the subquadriceps bursa The pain and swelling continued and were treated locally with massage About one month previous to the date of this report, following another relatively slight trauma, the femur was fractured and Figure 1-A



3 The typical location of *latent cyst* is in the mid-shaft of a long bone. It is presumably a cyst which developed early in life, became quiescent, and thereafter was displaced toward the mid-shaft by

marks will be confined to a few, concerning certain difficulties in diagnosis. In multiple myeloma there may be marked decalcification of the bones and areas of rarefaction upon which, roentgenologically,



Figs. 1 A and 1 B. Female, aged 26. cell tumor. 1 A, taken Feb. 16, 1932. roentgen therapy.

Pathologic diagnosis. Osteolytic giant-  
1 B, taken Sept. 16, 1932, after deep

the growth of the bone. The patient in this condition is apt, therefore, to be older and the symptoms of longer duration. The bone near the defect may be strengthened by a thickening of the walls of the cavity. In the absence of this increase in density of the surrounding cortex it is impossible to differentiate the lesion from the rare instances of central chondroma. Metastatic malignancy or myeloma of this size would have thinned and perforated the cortex to a very considerable degree. This will be referred to later.

4 *Osteitis fibrosa cystica* already has been discussed thoroughly and our re-

one would make the diagnosis, yet microscopically there is no tumor. Such cases have often been associated with metastatic deposits of calcium in the lung, gastric mucosa, and kidneys, characteristic of parathyroid hyperfunction (Bulger and Barr (1)). Klemperer (8) reported a case of parathyroid tumor in association with carcinoma of the breast and bone metastases which certainly would have given rise to considerable confusion, if studied only roentgenologically. Determination of the serum calcium would be of diagnostic importance, since hypercalcemia is not found in metastatic malignancy, com-

and it may be multiple. Besides the long bones, the bones of the face, the pelvis (Fig 3), the skull (Fig 4), the vertebrae, the ribs, and the tarsal bones are subject to the disease.

*Angioma*—The differential diagnosis of the simple loculated type of giant-cell tumor from angioma in the long bones may be difficult. Typically the angioma occurs in the metaphysis adjacent to the epiphyseal line. Its appearance has been described as being most like that of a peculiar soap bubble. The loculations of angioma are somewhat smaller than those seen in giant-cell tumor and within them is seen a fine, fibrillary network. The tumor may extend into the marrow cavity. Pathologic fracture is very rare. The cortex is not expanded but is partially eroded so that the shell of bone may be paper-thin. The periosteum may be raised above the cortex but is intact. The appearance of angioma in a flat bone is, of course, entirely different and does not fall within the realms of this discussion.

*Chondroma*—Chondroma when it occurs as the typical, small, translucent, and rarefied area centrally in the shaft of the bones of the hands or feet is not difficult to diagnose. A case was observed by us which had the unusual feature of complete perforation at one corner of the lesion. We do not believe, however, that this has any definite relationship to the pathologic report of chondromyxosarcoma. We believe that the lesion is essentially benign.

*Metastatic Osteomyelitis of the Humerus*—A case (Fig 5) is introduced at this time to demonstrate a lesion which has destroyed a large area of the cortex, has the smooth punched-out appearance of a cystic or metastatic lesion, but in which the diagnosis of metastatic osteomyelitis is made by noting the irregular bone reaction about the lesion, extending down the shaft, and the slight irregular periosteal reaction about the local lesion. The diagnosis was confirmed by operation and pathologic examination.

*Osteolytic Osteogenic Sarcoma*—It appears to us that the primary malignant



Fig 5 Metastatic osteomyelitis (operation)

osteolytic tumors of bone are best classified for roentgen diagnostic purposes into the following three groups, based on the gross and, therefore, roentgen appearance rather than on the histogenetic basis which has been so ably suggested by Geschickter and Copeland (5). We have found this grouping more useful for practical purposes.

1 *Giant-cell sarcoma (chondroblastic sarcoma)*—This type is practically indistinguishable from giant-cell tumor roentgenologically. It is usually metaphyseal in origin, early invading the epiphysis but rarely invading bone in the opposite direction. Typically, as in giant-cell tumor, it shows a central area of multilocular destruction. When the cortex is



Fig 3 Giant cell tumor of ilium

shows practically the same appearance as that taken elsewhere immediately following fracture. It will be noted that there is an unusual degree of bone absorption about the site of fracture, with relatively little evidence of callus formation. With immobilization, the osteolysis continued and there was no evidence of bone regeneration or healing. Blood Wassermann was negative. A biopsy made at this time was considered unsatisfactory as studied at this institution. The films and history were reviewed at another institution and considered as revealing osteolytic sarcoma. However, a subsequent biopsy at this hospital showed a typical giant-cell tumor structure and the patient was treated with roentgen radiation.

The osteolysis continued (Fig 1-B). The patient has passed from our observation but the family physician informs us that roentgen therapy was continued and recalcification has begun.

In general, roentgenograms in these cases give evidence of a hazy, homogeneous mass, filling the space occupied by the dissolved bone, frequently extending beyond the cortex and pushing the soft tissues ahead of it. The periosteum is not sepa-



Fig 4 Giant cell tumor of skull. Arrow points to lesion. (The scratch is on the film and has nothing to do with the pathologic condition represented.)

rated, there is no reactive triangle. There is no bone structure visible in the tumor. The edges of the adjacent bone appear healthy and smooth. The epiphyseal line does not act as a barrier. Of particular importance is the fact that these giant-cell tumors go on to progressive lysis, so that, as in the present case, the entire lower end of the bone is destroyed. Pathologic fracture often is the first and only symptom. It was noted in the present case that after heavy roentgen therapy, the osteolysis progressed to an even greater degree, and this has been noted before in this type of case. Yet often, if a sufficient period of time is permitted to elapse, bone regeneration does take place in most unexpected instances. This happened in a case which we judge to be similar to our own, referred to by Derr (3) at the meeting of the American Roentgen Ray Society in 1931.

The suggestion of Herendeen (6) that on these grounds roentgen therapeutics be used diagnostically must be accepted with caution. In Figures 2-A and 2-B there is demonstrated an osteolytic sarcoma, with recalcification after heavy roentgen therapy, the patient dying of pulmonary metastases three months later.

Giant-cell tumor is not necessarily confined to the end of a long bone; exceptionally it may occur elsewhere in the shaft

was an encapsulated tumor, attached to the head of the fibula, pushing the soft tissues aside, while the third was a diffuse process simulating multiple myeloma. No such cases have come under our observation. They are mentioned merely to indicate a possible further group.

*Solitary Myeloma*—The roentgenologic appearance of diffuse myeloma is quite well known. As a single lesion, however, it is not common but has been reported at intervals, particularly in the English literature. It appears under various other names such as "plasmocytoma," "reticulum cell sarcoma," "primary lymphosarcoma," and "large round-cell sarcoma." These are probably all within the group of multiple myeloma which Ewing defines as a specific malignant tumor of bone marrow arising probably from a single cell type, characterized by multiple foci of origin, a uniform structure consisting of plasma cells or their derivatives, and rarely metastasizing. The solitary lesion appears as a large rounded, punched-out area extending peripherally from a central focus in the medulla. Its edges are well defined, there is no bone reaction, and there is a rapid thinning of the cortex which overlies the lesion. Early perforation occurs, followed finally by complete melting away of the cortex (Fig 6). The lesion usually, as in metastatic carcinoma, is at the site of a nutrient artery. The lesion may be solitary or a few similar lesions may appear subsequently in other bones. Although pathologically these tumors infiltrate surrounding tissues after perforating the cortex, this is not an outstanding feature roentgenologically. When they occur at the common site of metastatic carcinoma, as, for example, the intertrochanteric region of the femur, they are indistinguishable from it. They do occur also, however, at unusual sites such as in the bones about the ankle joint and those about the elbow.

Chloroma, a rare, single, destructive lesion arising near the orbit, will simulate multiple myeloma even under the microscope. The differential diagnosis is usually made clinically.

*Solitary Metastasis*—Solitary metastasis occurs with sufficient frequency to make it of considerable importance in differential diagnosis. Copeland (2) states that skeletal metastasis from carcinoma of the breast is solitary in 25 per cent of the cases. The majority of these solitary lesions occur in the vertebrae, pelvis, or femora. They are usually osteolytic. From the roentgen examinations solitary deposits were found in 60 per cent of hypernephromas metastasizing to bone. The evidence of solitary osteolytic bone metastases from carcinoma of the thyroid or lung appears to be at least as high as this, perhaps even higher. There is almost always an initial medullary involvement, with subsequent destruction of the cortex from within. There is practically no periosteal reaction. While the usual site of the tumor is at the entrance of the nutrient artery in the femur, it often occurs well above this site. Sometimes a mottling, due to increased density of bone, occurs within the area of destruction and there is thickening of the cortex above and below the site of metastasis, due to bone repair. Microscopically there are almost always both osteoblastic and osteoclastic phenomena, one or the other predominating, so that an occasional roentgen finding of the above-described character is to be expected. After deep roentgen therapy there is often evidence of considerable bone repair. The differential diagnosis of solitary metastasis from osteolytic sarcoma, particularly in the pelvis or spine, may be impossible. It is said that the sarcoma has a more definite edge separating the disease from the healthy bone and that it grows more rapidly. In the long bones, early stages of metastases are apt to be central, whereas the corresponding stages of sarcoma are apt to be subperiosteal. Since, however, the latter lesion rapidly becomes central and there do occur subperiosteal deposits of metastatic malignancy carried by the lymphatics, this differentiation is not of much practical use.

Time has permitted only the demonstration of cases of osteolytic neoplastic processes whose outstanding or only mani-

perforated, the periosteum is raised, but there is no bone formation from its inner side. It is probably in this group that the so-called malignant giant-cell tumors belong. Ewing (4) noted that such a tumor

and commonly involves the shaft of the bone either in its middle area or its metaphysis. There are areas of medullary bone destruction of a worm-eaten appearance, without any definitely circumscribed



Fig. 6 Solitary myeloma, "pneumocystoma" (pathologic diagnosis)

is from the very beginning a definite destructive process, invasive, and with the structure showing spindle cells.

2 *Osteolytic sarcoma — cartilaginous form*—This type usually occurs in young individuals, there being a central area of irregular destruction extending through the expanded cortex, with resulting periosteal reaction. In early cases the destruction is subcortical and usually in the region of the epiphysis. The cortex is thin, later melting away. In this case the periosteal reaction may take the form of the "reactive triangle" of Kolodny. (Note Figs 2-A and 2-B.)


3 *Osteolytic sarcoma — fibro-osseous form*—This type usually occurs in adults

margin and without new bone formation. Some of these centrally developing tumors are pathologically the malignant bone aneurysms.

Incidentally, Stewart (10), of the Memorial Hospital, has recently described three cases of perithelial, alveolar, or diffuse bone tumors, with pseudo-epithelial, spindle, or polyhedral cells, which stain with Sudan III, and are thought to take origin in the fat tissue of the marrow. There are also many giant cells present. These tumors, he feels, are best described as primary liposarcomas. In one case, there was very nearly complete destruction of the radius and partial destruction of the ulna, with pathologic fracture. Another

# PERICOLITIS INVOLVING THE CECUM, ASCENDING COLON, AND HEPATIC FLEXURE, FROM THE STANDPOINT OF THE SURGEON<sup>1</sup>

By ARTHUR G. FREY, A.B., M.D., F.A.C.S., *Chicago*

PERATIVE surgery has contributed in a great measure toward the solution of many diagnostic problems. The rôle which surgical exploration has played in the clarification of the pathologic basis of symptoms referable to the abdomen requires no elaboration. There is, however, one phase of abdominal involvement which has been the subject of considerable speculation and discussion—I refer to the matter of pericolic, or pericolic membrane, more familiarly designated as Jackson's membrane, as an etiologic factor in abdominal complaints.

Jabez N. Jackson, in a paper presented before the Western Surgical Association in 1908, definitely described a membranous veil in connection with the cecum, ascending colon, and hepatic flexure which he felt was of great significance in the causation of abdominal disorders. I can do no better than quote, with his permission, some portions of his original article in which he incorporates a report by Frank Hall, pathologist to the Kansas City General Hospital, describing the condition as found at postmortem as well as on the operating table.

"The specimen of ascending colon which you have presented to me as a type of the pericolicitis you have been interested in exhibits the following gross and microscopic features. The specimen presents the caput coil with attached appendix, the ascending colon, and short segment of the transverse colon.

"From a point just at the hepatic flexure to 3 in. above the caput there spreads from the parietal margin over the external lateral margin to the internal longitudinal muscle band a thin vascular veil in which long, straight, unbranching blood vessels course, most of which are parallel with each other and take a slightly spiral direction over the colon from the outer upper peritoneal attach-

ment to the inner lower portion of the gut, ending just above the caput. The appendix is not implicated in any way.

"Coursing with the blood vessels are numbers of shining narrow bands of connective tissue which gradually broaden as they go, and end in a slight fan-shaped attachment at various points on the anterior and inner surface of the colon. At these points of attachment the gut is held in rigid plication.

"The entire specimen conveys to the eye the idea that an edematous fluid lies beneath this delicate membrane, and reminds one of nothing so much as an edematous arachnoid, so often encountered on removing the dura mater from the brain of a dead alcoholic. The colon seems placed in a diaphanous bag slightly too short to contain it without wrinkling. At the beginning of the hepatic flexure the drawn membrane particularly angulates the contained colon. Here and there are spots and tags of fat beneath the cobweb. On handling, the specimen of colon slips about in its bag without entire freedom as a fetus without its amniotic sac. A portion of the parietal peritoneum has been removed with the colon and shows that the membrane and blood vessels arise in, and are continuous with, the structures of the parietal peritoneum, as it sweeps over the colon. The entire structure seems to be peritoneum, loosed from its close connection to the abdominal wall and colonic surface by some serous exudate, after which the particular vascularization and connective tissue banding has occurred as a chronic reaction to irritative influence.

"In addition to this description we would add some observations of the condition as observed in quite a number of living subjects seen in the course of surgical operations. The transparent, vascularized veil-appearance of the membrane strikes one's attention very forcibly, with the parallel bright red vessels running with the long axis of the ascending colon. In some instances it appears as though the membrane comes on to the colon from the lateral parietal wall just above the cecum and courses directly upward, to disappear beneath the liver on the upper superior layer of the transverse mesocolon. In other instances it seems attached like an adhesion to the under surface of the liver, well anterior to the normal peritoneal reflection. Again, in other cases, it appears as though it had begun above and descended on the colon to its

<sup>1</sup> Presented before the Radiological Society of North America at the Seventeenth Annual Meeting, at St. Louis, Nov. 30-Dec. 4, 1931.

festation is in the skeletal system. These cases are some of the more unusual examples, unusual in regard to appearance, occurrence, site, or age of incidence. It is hoped that this presentation will serve to emphasize the fact that it is necessary to marshal all available data before a diagnosis is ventured from a roentgen film. The lesion should be studied with regard to whether it is single or multiple, or whether or not it is part of a systemic disease. Upon the roentgen film the appearance of the area of lysis, its location, whether central or subperiosteal, the degree to which the cortex is destroyed or expanded, the amount of periosteal reaction, the presence or absence of bone reaction are of greatest importance. In the unusual case, biopsy with thorough examination of adequate material should be resorted to early, although occasionally it is wise to prepare the lesion by deep roentgen therapy. This form of therapy certainly can do no harm and is practically always

indicated in the osteolytic bone tumors. Recalcification will often occur in unexpected instances providing sufficient time is allowed but this should not be used diagnostically.

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mists have reported the occurrence of pericolic membrane in postmortems immediately following birth

*Acquired*—The presence of pericolic membrane has been interpreted as an effort on the part of Nature to correct a developmental defect, which resulted in a failure to obtain normal fixation of the ascending colon. In normal individuals the ascending and descending colon should be fused to the parietal peritoneum in a way which practically fixes the large bowel. Embryologists and anatomists, however, have made the observation that from 20 to 40 per cent of persons do not develop normally in this respect, resulting in a mesenteric defect which most frequently involves the cecum and ascending colon—the primitive mesentery, as it were, a reversion to the normal arrangement in quadrupeds.

As a result of this defect in normal fixation of the ascending colon and depending upon the extent of this defect, varying degrees of mobility of the cecum and ascending colon result. To this unusual mobility is due visceral displacement, associated with more or less extensive membrane formation, which, as I have said before, has been regarded as an effort upon the part of Nature to compensate for a developmental defect. In many instances, this compensatory effort is successful. Very often, however, this corrective process "goes wild," thereby causing a multiplicity of organic and functional abnormalities of the bowel, with their consequent train of symptoms.

*Inflammatory*—The frequent association of chronic appendicitis, colitis, and chronic involvement of the gall bladder in the presence of these membranes, and the frequent involvement of the organs mentioned by the pericolic membrane has led to the feeling that there may be an inflammatory basis for their presence.

#### SYMPTOMS

Although the pathologic basis for these membranes be more or less indefinite,

their presence as observed by surgeons explains in a most convincing manner the possible basis for the many symptoms referable to chronic involvement of the abdominal cavity. These broad bands, by their encroachment upon the colon, frequently cause trouble at the ileocecal junction, and are capable of producing a narrowing of the lumen of the bowel, also abnormal angulation at the hepatic flexure. If very extensive, they may also involve the duodenum and jejunum. In fact, no portion of the abdomen is exempt from their influence. I do not propose to delve extensively into the symptom-complex that may result from the pernicious action of these membranes. Studies in many instances have shown that they are a definite factor in the production of intestinal stasis, ranging from mild forms of chronic constipation to severe obstruction. These membranes, in most instances, fall short of properly supporting the cecum and, as a result, we find this condition associated with enteroptosis, the functional and organic symptoms of which are familiar to clinicians. The symptomatology in many cases diagnosed as chronic appendicitis is based upon the presence of pericolic membranes involving the cecum and appendix, and the removal of the appendix has in many cases not produced the desired result because the presence of pericolic membrane as a factor in the production of the symptoms was overlooked. The symptoms in the presence of a pericolic membrane may simulate gall-bladder disease, chronic gastro-intestinal involvement, and even pelvic trouble, in fact, pericolic membrane may be the basis for the symptoms involving the organs mentioned.

#### DIAGNOSIS

The diagnosis of pericolic membrane is based on the history of the case, evaluation of the symptoms, physical examination, and x-ray study. Suggestive points in the history and symptoms include

- 1 History of chronic pain and discomfort in the region of the cecum and



termination, usually just above the cecum. We have also seen it pass across and upward to the transverse colon, which, in some instances, was apparently drawn down by the membrane, practically paralleling the ascending colon to the level of the cecum. In this case the gastric symptoms were marked as a result of the mechanical gastropnoia thus produced. In one instance this membrane was so dense as to lose entirely its apparent vascularity and transparency, and it looked like a solid sheet of organized fibrous tissue, beneath which the ascending colon was so lost that it could not be seen at all until the membrane was divided and brushed aside when an apparently normal, though contracted colon became evident.

"In no instance does this membrane resemble our ordinary conception of an adhesion. It is never adherent to the abdominal wall nor to any contiguous loops of small intestine. Instead, it resembles more closely than anything we can describe a thin pterygium. In recent cases the membrane is quite free and produces but limited restriction to the underlying colon. In more advanced and characteristic cases it seems to bind the colon close to the posterior abdominal wall and produces such marked angulations and convolutions of the colon as practically to produce a stricture of its lumen, in fact, in one case seen in autopsy when a stream of water was caused to flow into the cecum through the ileocecal valve, the cecum distended almost to bursting, and yet none of the fluid would pass through the ascending colon and past the hepatic flexure until it was milked through with the fingers. It is also noteworthy that in the large majority of cases the cecum was not involved in the membrane at all, nor was the appendix involved, except when it occupied an ascending position at the outside of the colon, and then it was covered by the membrane as it was reflected on to the colon from the lateral parietal wall. The appendix in almost every case was rather small and sclerotic. We have seen the membrane in one case in which there had been, years before, an appendicular abscess, which was drained. In this case the cecum was likewise markedly involved in the membrane. The angulation of the colon is generally most marked at the hepatic flexure. There is always a very loose space where the membrane can be easily picked up at the outer angle, where it passed from the colon to the outer parietal wall."

From the description presented it becomes evident that we have under consideration a condition which offers many

potentialities from the standpoint of pathogenesis in its relation to abnormal conditions involving the cecum, appendix, ascending colon, and hepatic flexure. Studies along this line have shown that these membranes are not necessarily limited to the areas mentioned, however, the portions of the intestines referred to constitute the greater number of clinical problems. The recognition and proper evaluation of pericolicitis as a factor in abdominal involvement must not be overlooked by the surgeon. In many cases where an appendix has been removed upon the diagnosis of chronic appendicitis, the reason for the patient's failure to obtain relief has been the presence of a pericolic membrane which was not taken into consideration as a causative factor.

#### ETIOLOGY

The pathogenesis of the pericolic membrane has been the subject of considerable study. Opinions vary as the basis of their origin, but no definite conclusion has as yet been reached from the etiologic contentions which have been advanced. Studies in comparative anatomy of the abdomen reveal essential differences in abdominal structure in quadrupeds as compared to human types. In quadrupeds the liver is suspended by the mesentery and the large intestine has a long mesentery and is freely movable. In man, the liver is fused with the diaphragm and the ascending colon and the two flexures are normally fixed to the posterior abdominal wall without the intervention of a mesentery. This is apparently due to prenatal fixation in man by adhesions between the parietal and visceral peritoneum in an effort to maintain the organs mentioned in their respective positions, thereby preventing them from dropping into the lower abdomen.

From an etiologic standpoint, the causes of pericolic membrane have been divided into (a) congenital, (b) acquired, and (c) inflammatory.

*Congenital*—Embryologists and anatomo-

# THE RECORDING OF CARDIAC MOVEMENTS AND SOUNDS BY THE ROENTGEN RAY (KYMOPHONOROENTGENOGRAPHY)<sup>1</sup>

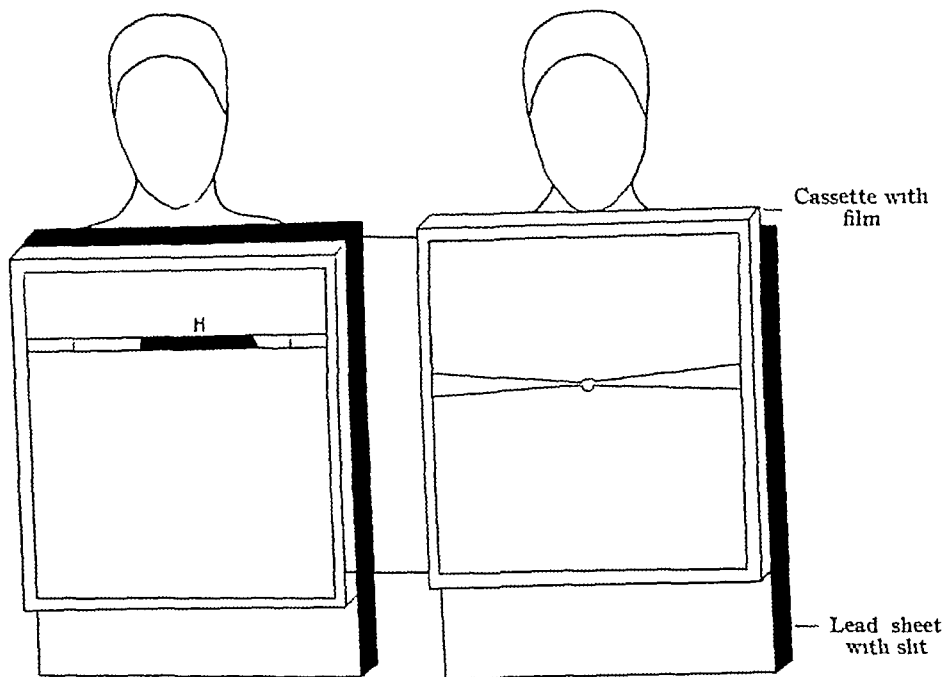
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## PART I

OUR knowledge of the movements of the heart is based on animal experimentation, on transitory observations of the opened chest, and on examination by roentgen-ray methods on this subject, because the rapidity and complexity of the movement makes an accurate analysis difficult. Cinematography, either by photography of the fluoroscopic image or by direct serial roent-



Figs 1-A and 1-B In the ordinary kymogram such as is used in the physiologic laboratories the up-and-down movement of a lever of a tambour is recorded in the form of a wave on a moving surface (blackened drum). In the roentgen-kymogram, however, the moving pointer is replaced by the shadow of a moving portion of the heart surface and the drum by a moving photographic film. To get the movement of only a small portion of the heart surface, the chest is covered by a sheet of lead in which there is a slit. The slit is placed opposite that portion of the heart it is desired to study. A portion of the heart as it would be disclosed on the fluoroscopic screen through the slit in a lead sheet, is shown (Fig 1-A) as an expanding and contracting black band. If the fluoroscopic screen is replaced by a moving film (Fig 1-B), the movement of the band of heart shadow is now recorded on the film as a shadow with serrated edges. There is no limit to the extent of the film, which may be moved in front of the slit under such conditions. However, the movement of only a single point of the right and a single point of the left heart is thus recorded. Instead of a single slit, multiple slits may be utilized (Fig 1-C). A record is now obtained of the movement of multiple points on the heart surface. The movement of the film must now, however, be limited to a distance just short of the distance between slits to avoid overlapping (Fig 1-D).

Fluoroscopy, technically the simplest of the roentgen methods, throws little light on this subject, is impractical for routine studies and is complicated both in technique and analysis.

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept 25-30, 1933

There is now available, however, a sim-

appendix aggravated by distention of the cecum and relieved when this distention is less pronounced or disappears

2 Chronic constipation which is resistant to the usual corrective measures, especially when this intestinal stasis appears to be progressive in character

3 Chronic dyspepsia which is not associated with any definite evidences of disease of the stomach or gall bladder

4 A history of so-called nervous dyspepsia or spastic colitis which persists in the face of medical measures

Suggestive physical findings include

1 Findings of a definite enteroptosis in the presence of the symptoms mentioned

2 Abnormal mobility of the cecum

3 Abnormal fixation of the cecum

4 Abnormal distention of the cecum

The presence of physical signs suggestive of pathology in the right side of the abdomen, plus intestinal symptoms without any definite tenderness over the area involved, is a combination with which one frequently meets

On deep inspiration the cecum is forced down by fixation of the colon on pressure with the left hand in the right hypochondriac region. The cecum can be palpated with the right hand and its contour, mobility, and texture satisfactorily judged

The x-ray may be of definite value. The gastro-intestinal x-ray examination or the barium enema may reveal abnormal conditions of the cecum, kinks at the juncture of the cecum and ileum, and at the hepatic flexure, as well as narrowing or distortion of the ascending colon

In some cases the diagnosis may rest on an exploratory laparotomy, which I feel is indicated in many cases in which gastro-

intestinal symptoms of long standing fail to respond to non-surgical measures

#### TREATMENT

The treatment of pericolic membrane may be along palliative and radical lines. Palliative measures in cases with persistent symptoms are, as a rule, unsatisfactory

Radical measures properly applied are of definite value. I employ a right rectus incision, exposing the peritoneal cavity. The cecum, appendix, ascending colon, and hepatic flexure are carefully explored. The condition, location, and mobility of the areas mentioned are carefully considered and the pathologic effect of the membranes evaluated. The surgical treatment of these membranes and of the colon depends upon conditions encountered. Any abnormality met with is corrected by proper section and treatment of the offending pericolic membrane. Kinks and contractions are eliminated and every effort is made to obtain fixation of the ascending colon which will permit normal readjustment and contour. I will not at this time describe in detail the types of operations required to meet different abnormalities encountered. I wish to state, however, that my surgical management of these situations is more or less conservative. I am not greatly inclined toward "short-circuiting" operations, which in my experience with these cases I have found of practically no necessity

In conclusion, I wish to emphasize the desirability of the consideration of surgical treatment of gastro-intestinal involvement of the chronic type which fails to respond to the ordinary non-surgical measures. I feel that the surgeon, in many of these cases, has a great deal to offer the patient in his search for relief

the pulsatory motion direct and transmitted, of the pulmonic structures are recorded

when released, the film falls by its own weight. On the front of the frame, between patient and film, there is mounted a

Comparison of the technic employed by

TABLE I—TECHNIC USED BY VARIOUS INVESTIGATORS

	Slit	Rate of film movement per second	Exposure	Equivalent exposures per second	Distance
Goett	3 mm	6 cm	3 5 sec	6	50 cm
Crane	2 mm	5 cm	1 sec	25	60 cm
Knox	2 mm	5 cm	8 sec	3	(?)
Stenstrom and Westermarck	1 mm	2 cm	2 sec	10	75 cm
Stumpf	2 mm	5 cm	2 sec	12 $\frac{1}{2}$	80 cm
Stumpf	0 5 mm	1 2 cm	3 sec	8	100 cm
Hirsch	0 4 mm	1 2 cm	1 sec	30	70 cm

various workers shows differences in the size of the slit, the speed of movement of the film, and the focal distance (Table I). The ideal arrangement would appear to be a very narrow slit, a high speed of film movement, and a long focal distance. But the smaller the slit, the faster the movement, the longer the distance, the greater would be the intensity of radiation necessary to make a satisfactory kymogram at a two-meter distance. Thus, with 0 4 mm slits and 1 2 cm per second film speed it is necessary to energize the tube with 300 ma at 100 K V over a period of one second for a distance of 200 centimeters. It is apparent, therefore, that at present technical limitations to the production of the ideal kymogram exist. The technic followed in this work is the closest approach to these conditions, considering present limitations in equipment.

The apparatus constructed by the hospital physicist, Myron Schwarzschild, is of the multiple-slit type. It consists of an unpervious plate with slits of equal width, a mechanism for moving a film at a constant speed behind a grid, a mechanism for energizing the x-ray tube shortly after this movement begins, and for cutting off the energization of the tube shortly before the film movement ends.

The arrangement is essentially a grid diaphragm mechanism with the springs removed. In place of the grid there is mounted a carriage to hold a 14 × 17 cassette. This is mounted vertically, so that,

lead grid consisting of slits 0 4 mm wide, spaced at a distance of 12 mm from each other. The grid-diaphragm contactors have been so rebuilt that the exposure can be adjusted by means of a speed control. A time marker record, in fifths of a second, is impressed on the film during its exposure.<sup>3</sup>

Since the width of the slits is only one-thirtieth of the distance traversed by the film while the exposure is being made, the set-up must be such as gives a perfect film in one-thirtieth of the actual exposure time. An exposure of at least one second is necessary to cover at least one cardiac cycle. Satisfactory kymograms may be made with 87 K V peak, 100 ma, at 70 cm distance, for the average chest. The

<sup>3</sup> This consists of a small electro-magnet mounted on the back of the fiber sheet in such a way as not to interfere with the motion of the mechanism or cast a shadow. The armature of this electro magnet is so extended as to project parallel to the edge of the film and near the edge. This extension casts a shadow on the film and at every impulse produces a projection on the recorded shadow. It is connected through batteries to a contact which is operated by clock-work or synchronous motor to close five times a second.

The synchronous motor driving the time marker may be the same one which drives the time marker of the electrocardiograph, so adjusted that the marks on the x-ray film come simultaneously with the fifth second divisions on the electrocardiogram. In order to determine the heart beats in the electrocardiogram which are recorded by the x-ray, another electro-magnet of similar construction is mounted in front of the electrocardiographic camera and actuated by the voltage applied to the x-ray transformer primary. A mark will thus be left on the electrocardiogram, showing when x-rays started and stopped, thus serving the double purpose of orienting and checking the timing mechanism.

ple graphic method of obtaining a permanent record of the movements of the heart on a single film. Essentially, this method is roentgenography through a slit diaphragm placed close to the object in mo-

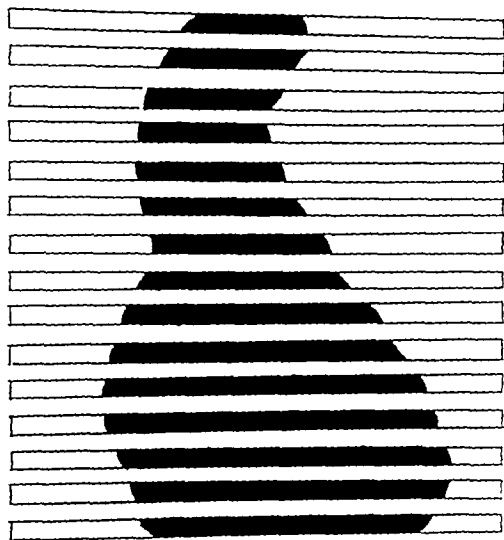


Fig 1-C (Diagrammatic)

tion, the recording film not being at rest as in ordinary roentgenography but moving at a constant rate of speed, at right-angles to the direction of the slit. Thus if the slit is horizontal the film moves in a vertical direction, if the slit is vertical, the film moves horizontally. The motion of the object in front of the slit is recorded on the film in the form of a wave or curve.

For the study of the movements of the heart by the single slit method the anterior thorax is placed against a lead plate having a slit several millimeters wide. By the aid of the fluoroscopic screen, the slit is so adjusted that it crosses the cardiac shadow at a desired level. The tube is placed behind the thorax, with its focal spot at the level of the slit. Fluoroscopy will now show the pulsating band-like shadow of a narrow section of the heart (Fig 1-A). If the fluoroscopic screen is replaced by a film, moving at a regular rate in a direction at right-angles to the slit (Fig 1-B), the mov-

ing cardiac shadow will be projected on the film as a continuous band whose edges bear waves corresponding to the movement of the particular portions of the heart exposed in the slit. The length of a record made in this way is limited only by the length of the film.

Such a single slit kymogram can trace the movement of only one or two points of the heart surface. It has the additional limitation of giving neither the general form and contour of the heart, nor the morphology of the other thoracic structures.<sup>2</sup>

In the multiple-slit method, the lead sheet against which the thorax is placed has many equally spaced slits (Fig 1-C). The length of the record of movement, of the particular part exposed in the various slits, is now necessarily limited in order to avoid overlapping of the records (Fig 1-D). The exposure is, therefore, limited to the time it takes the film to move a millimeter or so less than the distance between the slits. The length of the individual records is limited, therefore, but by making the slits narrow and decreasing the speed of motion of the film, a number of waves of each point sufficient for practical study may be obtained. By the multiple-slit method, not only is the motion of the entire heart and its vessels delineated, but

<sup>2</sup> This technical principle was first applied in the study of the heart action by the Polish physiologist, Sabat, in 1913, whose article on the subject attracted little attention. Later in the same year, Rosenthal (Munich) constructed a simple instrument which was used by Goett, who, in 1913, attempted an analysis of cardiac movements by this method. They used one and two slits.

In 1916, A. W. Crane in a paper on "Roentgenology of the Heart" reported studies made by this method and compared them with polygraphic and electrocardiographic curves.

Interest in the method then lapsed until 1929 when Knox of London developed a kymographic apparatus utilizing the more powerful sources of x-ray at his command. Credit is due to Knox for having pointed out the possibility of the application of the method not only in cardiology, but in the study of the movement of the diaphragm, stomach, and colon.

Stumpf in 1929, described a kymographic arrangement using multiple slits thus obtaining records of the movement of many points of the heart simultaneously. He has applied this method to other organs beside the heart as indicated by Knox.

the pulsatory motion direct and transmitted, of the pulmonic structures are recorded

Comparison of the technic employed by

when released, the film falls by its own weight. On the front of the frame, between patient and film, there is mounted a

TABLE I—TECHNIC USED BY VARIOUS INVESTIGATORS

	Slit	Rate of film movement per second	Exposure	Equivalent exposures per second	Distance
Goett	3 mm	0 cm	3.5 sec	6	50 cm
Crane	2 mm	5 cm	1 sec	25	60 cm
Knov	2 mm	5 cm	8 sec	3	(?)
Stenstrom and Westermarck	1 mm	2 cm	2 sec	10	75 cm
Stumpf	2 mm	5 cm	2 sec	12½	80 cm
Stumpf	0.5 mm	1.2 cm	3 sec	8	100 cm
Hirsch	0.4 mm	1.2 cm	1 sec	30	70 cm

various workers shows differences in the size of the slit, the speed of movement of the film, and the focal distance (Table I). The ideal arrangement would appear to be a very narrow slit, a high speed of film movement, and a long focal distance. But the smaller the slit, the faster the movement, the longer the distance, the greater would be the intensity of radiation necessary to make a satisfactory kymogram at a two-meter distance. Thus, with 0.4 mm slits and 1.2 cm per second film speed, it is necessary to energize the tube with 300 ma at 100 K V over a period of one second for a distance of 200 centimeters. It is apparent, therefore, that at present technical limitations to the production of the ideal kymogram exist. The technic followed in this work is the closest approach to these conditions, considering present limitations in equipment.

The apparatus constructed by the hospital physicist, Myron Schwarzschild, is of the multiple-slit type. It consists of an impervious plate with slits of equal width, a mechanism for moving a film at a constant speed behind a grid, a mechanism for energizing the x-ray tube shortly after this movement begins, and for cutting off the energization of the tube shortly before the film movement ends.

The arrangement is essentially a grid diaphragm mechanism with the springs removed. In place of the grid there is mounted a carriage to hold a 14 × 17 cassette. This is mounted vertically, so that,

lead grid consisting of slits 0.4 mm wide, spaced at a distance of 12 mm from each other. The grid-diaphragm contactors have been so rebuilt that the exposure can be adjusted by means of a speed control. A time marker record, in fifths of a second, is impressed on the film during its exposure.<sup>3</sup>

Since the width of the slits is only one-thirtieth of the distance traversed by the film while the exposure is being made, the set-up must be such as gives a perfect film in one-thirtieth of the actual exposure time. An exposure of at least one second is necessary to cover at least one cardiac cycle. Satisfactory kymograms may be made with 87 K V peak, 100 ma, at 70 cm distance, for the average chest. The

<sup>3</sup> This consists of a small electro-magnet mounted on the back of the film sheet in such a way as not to interfere with the motion of the mechanism or cast a shadow. The armature of this electro-magnet is so extended as to project parallel to the edge of the film and near the edge. This extension casts a shadow on the film, and at every impulse produces a projection on the recorded shadow. It is connected through batteries to a contact which is operated by clock-work or synchronous motor to close five times a second.

The synchronous motor driving the time marker may be the same one which drives the time marker of the electrocardiograph, so adjusted that the marks on the x-ray film come simultaneously with the fifth second divisions on the electrocardiogram. In order to determine the heart beats in the electrocardiogram which are recorded by the x-ray, another electro-magnet of similar construction is mounted in front of the electrocardiographic camera and actuated by the voltage applied to the x-ray transformer primary. A mark will thus be left on the electrocardiogram, showing when x-rays started and stopped, thus serving the double purpose of orienting and checking the timing mechanism.

kymograms have excellent photographic quality, as a rule, due to the action of the grid as a partial "scattering absorber"

The kymograms in this study were all made with the subject in the standing or

shadow. The form of the wave differs over different parts of the cardiac silhouette and is related to the chamber forming the contour

3 The cardiac shadow is no longer of

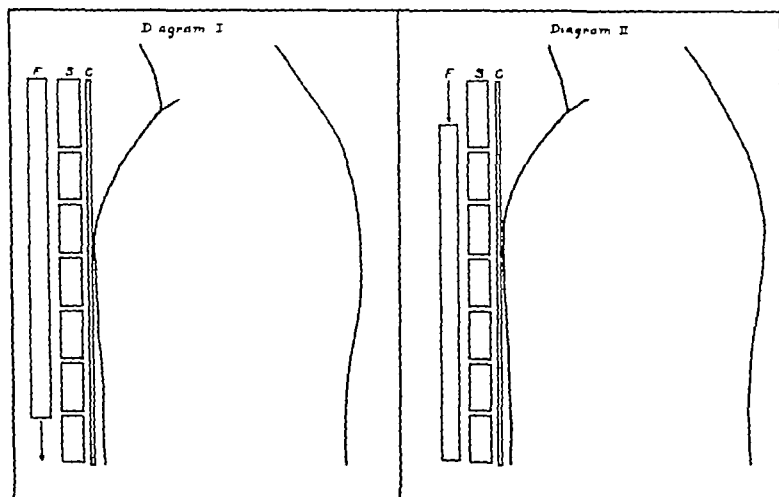


Fig 1-D C, control film S, lead sheet with slits F, cassette and film which move downward a distance slightly less than the distance between slits. Diag I, before, and Diag II, after movement of the film

sitting position, in inspiration and with the slit placed horizontally. If desired, a film without intensifying screen may be placed outside of the grid so as to obtain simultaneously an ordinary roentgenogram of the chest (Fig 1-D). The horizontal position of the slits cannot give absolutely accurate records of all the components of the complex cardiac motion, nevertheless it is suited for practical purposes because the main component of cardiac motion is the lateral thrust.

*Description of the Kymogram*—The kymogram differs from the ordinary roentgenogram in the following details (Fig 2)

1 It is crossed by regularly spaced white lines dividing the film into a series of bars

2 The entire contour of the median shadow shows a definite wave in each bar which crosses it. The wave is a record of the movement of a particular point of the structures shown in profile in the median

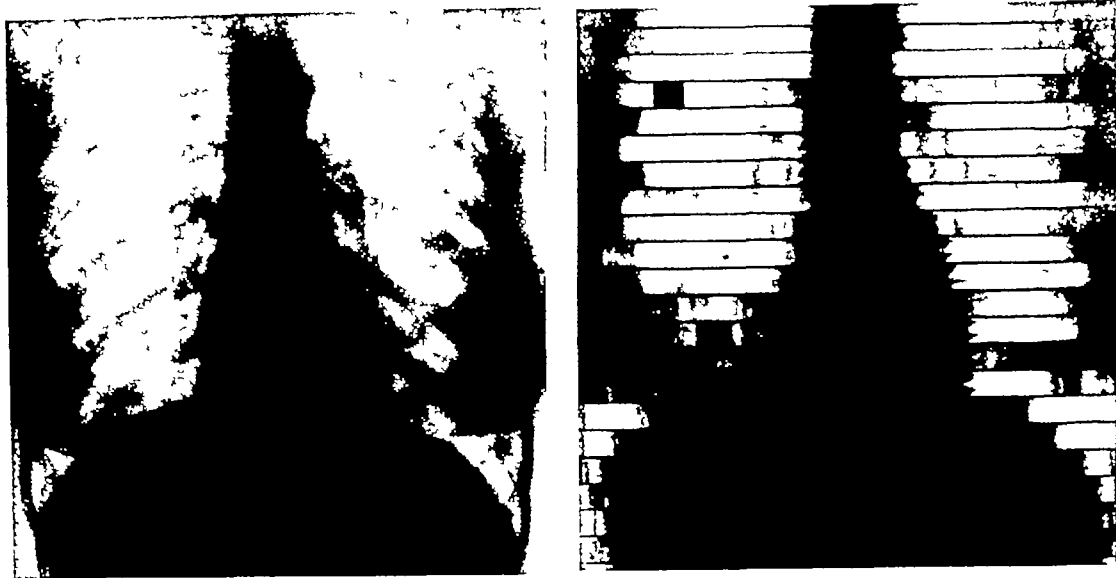
homogeneous density but within each bar there are zones of varying density, representing a gradual transition from light to dark. These zones are the record of the variations of the actual density of the heart in diastole and systole. The exact extent of this change in density has been measured by Stumpf with a densograph.

4 The usual pulmonic markings are shown as wavy lines.

5 The ribs are not discernible as such, and the peripheral contours of the pulmonic field consist of a series of vertical lines.

6 The diaphragmatic curves are replaced by bands in a step-like formation.

1 The white lines represent the edges of the impervious plate at the slits and are visible because the film moves just short of the distance between two slits. If it moved the entire distance, there would not be any such linear shadow but the waves would overlap—an undesirable condition. These white lines divide the pulmonic field



Figs 2 A and 2-B An ordinary roentgenogram of the heart (Fig 2-A), and a typical roentgen-kymogram of the same heart (Fig 2-B) The waves over the entire cardiac shadow are movement records of the particular portions of the heart These points are close enough together to give an accurate representation of the general contour Waves of different shape and size may be distinguished over different portions of the heart contour, due to a variation both in the time and amplitude of movement of the various chambers The peak of the wave represents the particular portion of the heart in maximum diastole and the deepest points of the valleys represent the position of the particular chambers of the heart in maximum systole Since the film moves downward, the diastole is the proximal leg and the systole, the distal leg The difference in the form and size of the ventricular, auricular, and aortic waves is striking Even in a normal heart the ventricular movement imposes its movement on the auricles so that peaks ventricular in character are seen over the adjacent portion of the auricles, in addition to the characteristic auricular waves At the junction point between ventricle and auricle, auricle and aorta, and auricle and pulmonary artery, waves characteristic of both chambers may be observed Since the exposure is 1 second, the distance between the black lines may be divided off into as many portions as is desired, representing fractions of a second By laying off on the waves of each bar a definite distance, corresponding to a certain fraction of a second, and connecting these homologous points, the shape and outline of the entire heart at that particular instant may be shown

and cardiac shadow into a series of bars These bars do not show homogeneous illumination At the periphery of the pulmonary fields some, for a varying distance, show no illumination over areas corresponding to the position of the ribs

2 If the contour of a structure has no movement or has movement absolutely parallel to the contour edge, the edge of the shadow is a vertical line If the contour has movement and this is at an angle to the contour edge, this movement is shown as a wave The kymographic wave permits analysis as regards form, amplitude, duration, and phase or time relationships

*Form*—The form of the wave with a definite rate of film motion depends on the character of the movement of the particular point of the heart A very sharp peaked wave is produced by an extremely rapid movement and change in direction

The movement may be so fast that its record is practically a horizontal line A dome-like wave represents a slow change in direction, a progressive increase and diminution in the speed of movement—a motion similar to that of a swinging pendulum (Fig 9-C) When the to-and-fro motion is not regular, the motion being faster in one direction, the faster motion produces a straightening and shortening of the particular leg of the wave (Fig 9-B) The legs of the waves may be straight or curved depending on the speed of motion Imposed on these waves are angulations, hooks, peaks, indentations, and terraces, representing the rapid changes in the direction of the movement of the cardiac muscle, movements of the heart as a whole, and local vibrations produced by currents of blood within the heart (Fig 9, a', b', c', d) The study of the wave thus gives in-



formation as to the speed, regularity, and direction of movement

In the analysis of the significance and meaning of the waves it is obvious that the outward thrust of the heart action (dias-

The crest of the wave represents the end of diastolic period or beginning of systolic, while the deepest portion of the trough represents the period of maximum systole or the beginning of diastole Since in the

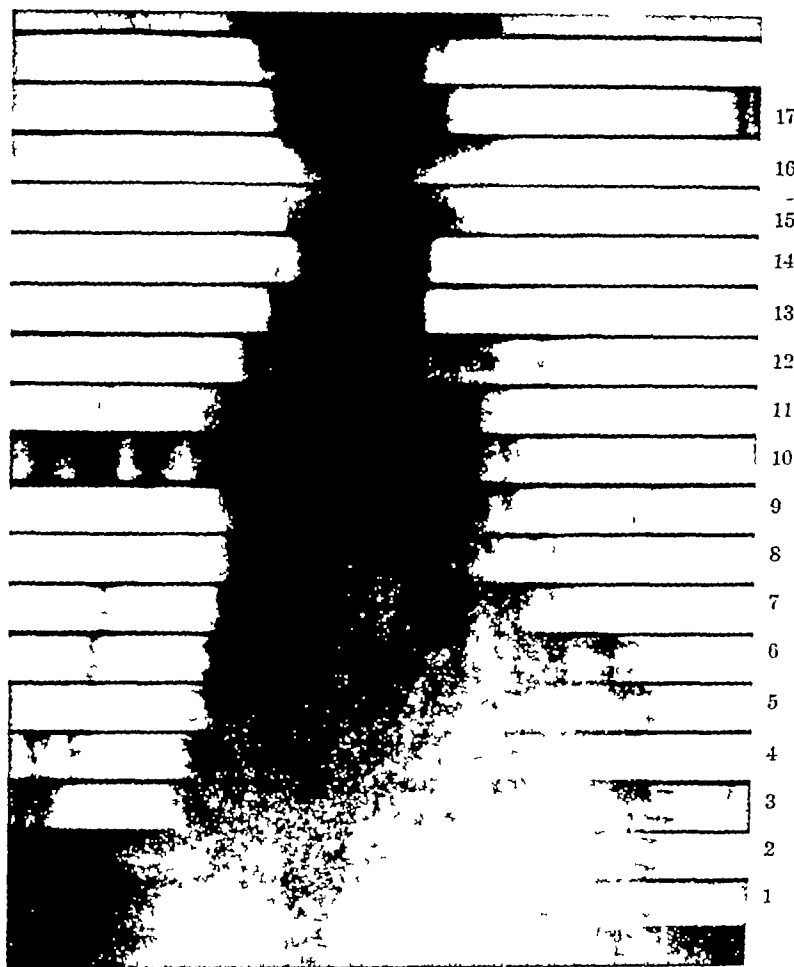


Fig 3 Normal kymogram of an asthenic individual with vertically placed heart From Bar 12 to Bar 17 the waves are those characteristic of the aorta In Bar 12 the wave is purely pulmonic Bar 11 shows the evidence of auricular motion in Bar 10 the wave is purely auricular in Bar 9 the wave begins to show ventricular characteristics such as are found over the remaining left border Note that the apex of the wave approaches closer to the upper edge of the bar as one proceeds down the left border indicating a sort of peristalsis of ventricular wall The small notch on the diastolic lumb in Bars 3 4 5 and 6 corresponds to the second sound and the serration at the peak of the wave corresponds to the first sound The right contour of Bars 3 4 and 5 shows definite ventricular motion (right ventricle) In the two bars above this the waves are both auricular and ventricular and in the next bar above this they are purely auricular The boundary of the particular chamber is that point where the ventricular wave gives way to a mixed wave

tole) produces one side of the wave and the inward thrust (systole), the other

kymographic apparatus here utilized the film moves downward, it is the proximal

side which is diastolic and the distal, systolic in origin, and the record is to be read from below upward

*Amplitude*—The change of position of any point is fully and completely registered when its movement lies parallel to the direction of the slit. If the movement is not a simple one, but complex and in a changing direction, only those components of the movement will be completely and accurately recorded which are in a direction parallel to the slit. It is important to bear this in mind since it serves to explain the waves of exaggerated amplitude occasionally to be demonstrated, particularly over the apical portion of the heart. In such cases, sharp, clear, and standard waves may be obtained by a change in the position of the grid so that the slits run at an angle to the vertical axis of the chest. When the motion is exactly parallel to the direction of the slit, the amplitudes of the waves may be measured by the ordinate

If the motion is not parallel to the direction of the slits, as is the case with the greater portion of the left cardiac border, particularly in cases in which the upper part of the contour runs obliquely to the direction of the slits, the amplitude may be determined by projecting corresponding peaks and troughs of two bars to the horizontal line bounding each bar and connecting these projections. The perpendicular distance between these lines is the amplitude. The measurement, however, does not indicate the exact amplitude of movement, for, with a focal distance of 70 cm, there is some magnification

While the shorter focal distance prevents teleroentgenographic measurements, it nevertheless has the advantage of emphasizing by slight magnification the more delicate and less perceptible portions of a wave

*Duration*—The duration of the wave (abscissa) depends on the frequency of the movement of the part and the speed of movement of the film. It is measured between two homologous points of the waves, either between two troughs or two peaks. The speed of the film movement being con-



Fig 4 Showing a patient in position for combined electrocardiographic and roentgenographic examination. The cage is essential for the production of undeviated E K G waves

stant and known, the actual duration of the wave may be easily determined. This estimation is simplified by checking the interval periods against the record of the time marker. The number of waves within the bar (between two white lines—frequency) varies directly with the rapidity of the heart chamber contraction

The greater contraction-frequency, the more compressed the wave, the less frequency, the more extended and flatter the wave. For comparison of the waves it is necessary to take the rate into consideration

formation as to the speed, regularity, and direction of movement

In the analysis of the significance and meaning of the waves it is obvious that the outward thrust of the heart action (dias-

The crest of the wave represents the end of diastolic period or beginning of systolic, while the deepest portion of the trough represents the period of maximum systole or the beginning of diastole. Since in the

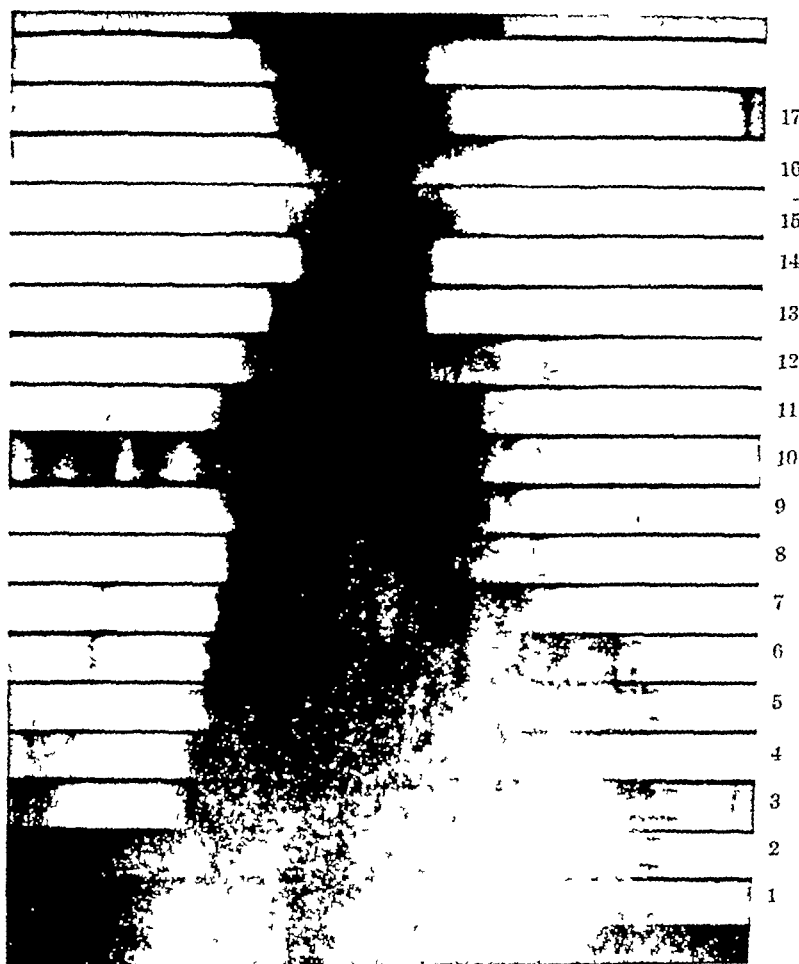


Fig 3 Normal kymogram of an asthenic individual with vertically placed heart. From Bar 12 to Bar 17 the waves are those characteristic of the aorta. In Bar 12 the wave is purely pulmonic. Bar 11 shows the evidence of auricular motion. In Bar 10, the wave is purely auricular. In Bar 9 the wave begins to show ventricular characteristics such as are found over the remaining left border. Note that the apex of the wave approaches closer to the upper edge of the bar as one proceeds down the left border, indicating a sort of peristalsis of ventricular wall. The small notch on the diastolic limb in Bars 3, 4, 5, and 6 corresponds to the second sound, and the serration at the peak of the wave corresponds to the first sound. The right contour of Bars 3, 4, and 5 shows definite ventricular motion (right ventricle). In the two bars above this the waves are both auricular and ventricular, and in the next bar above this they are purely auricular. The boundary of the particular chamber is that point where the ventricular wave gives way to a mixed wave.

tole) produces one side of the wave and the inward thrust (systole), the other kymographic apparatus here utilized the film moves downward, it is the proximal

4 The waves outside the heart border, in the pulmonic fields, are produced by the movement of the pulmonary vessels. Pul-

phase and periodicity. The waves of the pulmonary markings have greater photographic density, the nearer they are to the

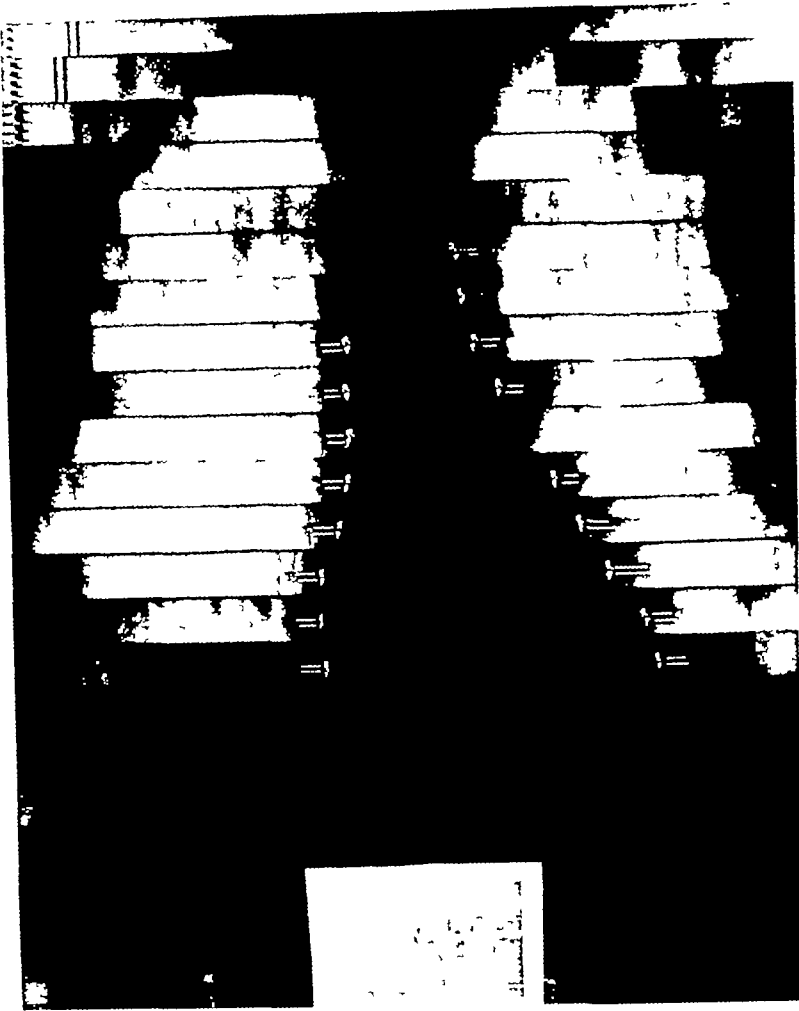


Fig 6 Roentgen kymogram showing the simultaneously made E K G record. Note the absence of any distortion of the E K G record. The exposure took place over the period indicated by the heavy line under the E K G waves. The relative positions of the peaks of the R and P waves are indicated on the kymographic waves. In the upper left hand corner are time marker divisions indicating fifths of a second.

monary waves are classified as primary and secondary. The primary are the result of intrinsic vascular motion, the secondary of transmitted motion. These waves vary in size and extent in different portions of the pulmonic field, being most distinct normally opposite the pulmonary conus, the ascending aorta, and at the base.

The vascular waves have all the same

median shadow. The presence of immobile shadows in juxtaposition to actively moving ones, must be discounted as being the shadows of projected distant structures. The study of the waves in the pulmonic field is important as indicating the distribution, size, number, and structure of the pulmonary vessels. Prominent vascular waves which do not decrease in ampli-

*Phase or Time Relationship*—To compare the time relationship of the various points of the waves—the distance from a fixed point—the upper or lower line of a bar is used. The distance of a certain point on

The analysis of the kymographic wave thus gives the character, direction, speed, and regularity of the movement of any particular part of the heart, and this depends upon the excitation phenomena, the

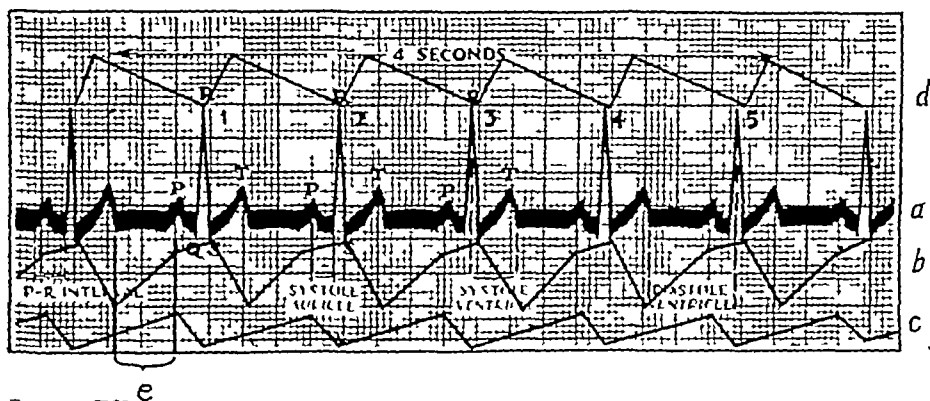


Fig 5 Diagram showing the relationship of the roentgen kymogram to the EKG record, made simultaneously. (b) represents the ventricular waves, (d) the aortic waves, and (c) the auricular waves. A comparison of the EKG and kymographic waves shows that the beginning of the Q-R-S wave precedes the beginning of systole by about 0.05. The P wave corresponds to the break in the diastolic limb of the ventricular wave and the T wave corresponds to the end of systole. The maximum outward thrust of the aorta is attained early in ventricular systole. The heart is in complete diastole during the period marked (e).

the wave from this line is measured with calipers and laid off from a corresponding fixed point on the wave of any particular portion of the cardiac shadow. In this way it may be determined whether the waves compared are ventricular, auricular, or vascular in origin. It is by this method that the components of the composite waves over certain portions of the contour are isolated and the origin of the waves in the cardiac or pulmonary shadows determined.

On comparing the time relationships of all the ventricular waves traced by the left border of the heart, there is to be observed a progressive advance of the point of onset of each wave, as if a migration of the wave had occurred. In other words, the visible evidence of ventricular systole appears earliest at the base and progresses downward, appearing last at the apex of the heart. The difference in time observed is about 0.05 second. The phenomenon is general, but varies under normal and pathologic conditions.

mass (thickness), and elasticity (tonus) of the contracting muscle, and upon the nature of the surrounding tissue.<sup>6</sup>

3 The photographic density of the heart shadow in the various bars is not homogeneous but consists of zones, or lighter and darker bands<sup>7</sup> corresponding exactly to the diastolic and systolic phases. The white zone (unilluminated) is a record of the density of the heart in diastole, the dark (illuminated) zone is a record of the decreased density in the anteroposterior diameter of the heart in systole. All pulsating structures show these density bands. These density changes are particularly marked in the region of the apex.

<sup>6</sup> The lungs appear to exert a dampening or cushion effect on the heart motions. Thus in a pneumothorax with retraction of the lung the motions are exaggerated, the waves showing increased amplitude while in the presence of pleural effusions or pulmonary consolidations the movements are of diminished amplitude.

<sup>7</sup> Irregularities in the movement of the film may produce horizontal lines in the frames. These however extend beyond the cardiac border and are very sharp and clear-cut.

the entire inferior border, is definitely right ventricle in all individuals. The waves over the upper part of the right contour are associated with auricular motion (Fig 3).

The study of the structure of the ventricular waves would indicate that the dia-

ventricles. This break in the contour of the diastolic limb always occupies relatively the same position normally, but shows considerable variation in lesions in which there has been interference with the auricular contraction.



Fig 8-4 The sound record of this case is placed in the aortic area of the kymogram. The second sound (middle peak of sound record) corresponds to a notch on the retracting limb of the aortic wave, a short distance after its beginning. The notch is due to vibrations produced by the current of blood arising from the closure of the aortic valves. An exactly similar condition is found in the pulmonary artery.

stolic ventricular enlargement takes place rapidly at first, then slowly. The primary outward thrust is due to rapid ventricular filling before active auricular contraction, and the second, slower segment, beyond the point of angulation, is due to the final action of the auricular contraction. The major part of ventricular filling seems to take place shortly after the ventricle goes into relaxation, and is in large part completed before the subsequent auricular systole, which begins at the point corresponding to the break in the diastolic limb of the ventricle. In the latter part of the diastole the blood enters the ventricle slowly, the length of this period depending on the duration of the entire cycle. If the heart rate is rapid, this period is shortened or absent. The systole of the auricle apparently plays but a minor rôle in adding blood to the

*Auricular Waves*—The waves of the auricles are characterized by a simpler structure and a smaller amplitude than the ventricular waves because the auricles do not have as vigorous motion as do the ventricles. The pure auricular wave consists of a low, slowly ascending limb (diastolic) and a relatively short rapid limb (systolic). Undefined auricular waves, however, can be made out only over a small portion of the upper part of the left and right auricles.

The time relationship to the ventricles is such that the peak of the ventricular wave corresponds to the deepest valley of the auricular wave. However, over the major part of the contour of the auricles, the dominant ventricular contraction imposes its own characteristic waves and the resultant wave is a composite of both



Fig 7 Sound record of the heart enlarged. The band represents the shadow of the lead strip moved by the oscillograph. The shadow of the lead strip has straight edges except at those points where it is moved by the heart sounds. The second sound is split in this record.

tude as they extend toward the periphery indicate change in the vessel, its content (congestion), or a change in the elasticity of the pulmonary parenchyma. Transmitted motion is differentiated from intrinsic pulsatory motion by the presence of changes in the photographic density in the latter.

5 The ribs show as band-like rectangular shadows which jut into the pulmonic field. The shadow is most dense at the periphery of the pulmonic field which now is bordered by a series of rectangular shadows with relatively illuminated centers, which corresponds to the cortex and medulla of the ribs. If necessary, the actual position of the rib shadows may be reconstructed from these rectangles.

6 The smooth convex contour of the diaphragm is broken up into a series of steps—shortest at the center of the dome and longer toward the costophrenic spaces. The actual position of the domes may be obtained by connecting homologous points on these step-like shadows.

Characteristic curves are found for the different portions of the cardiac contour which are related to the chamber responsible for the contour.

*Ventricular Waves*—These waves consist fundamentally of a sharp smooth inward limb representing systole, followed by a bent limb representing diastole. Two components are distinguishable in the diastolic limb—an acutely rising portion which is followed by a more gradual rise

to the point of maximum dilatation. This is cut abruptly by the beginning of the next systole. There is apparently no pause in the cardiac movement; the so-called diastolic rest period does not appear normally.

Imposed on the limbs of the waves are notches, indentations, and low sharp peaks. These represent vibrations, some of which correspond in time to the first sound of the heart and are, therefore, due to movement phenomena associated with it, while some represent movement imposed on the ventricle by other chambers and some, the movement of the heart as a whole.

The curve is not, therefore, merely a simple volume curve of the ventricle, but a rather complex tracing of the movements of the heart, both those due to actual muscular contraction of the individual chambers and of the heart as a whole.

The waves observed over the left ventricle are characteristic, though they vary somewhat in form. The simple angular form is most commonly found in a small segment of the upper part of the ventricular contour, while the remaining portion of the ventricle shows the trapezoid or rounded form. As the apex is approached the rounded form appears. In adults, in the aged, and in hypertrophied hearts, the apex may show practically no waves, indicating a diminution or absence of lateral motion.

The wave of the right ventricle is of the same type as that of the left ventricle. The duration and amplitude of the systolic portion of the wave is the same as that of the left ventricle. The diastolic phase may differ slightly from that of the left ventricular wave in a delay of two-fifteenths of a second. This may be due to the superposition on the ventricular waves of motion of the heart as a whole.

Ventricular waves are found over the left cardiac contour, beginning at a point just below the left auricular bulge and extending over the entire left lower border, around the apex. They are also visible on the lower third or half of the right cardiac border. This would indicate that the lower part of the right contour, as well as

systole The peak of the wave is attained just after the beginning of ventricular systole From this peak the wave shows, at first, a rapid descent, broken by a notch and then a slow descent The notching

rest should be compared with others taken only at rest, and those taken during exercise with others taken under the same conditions Exercise which increases the frequency and the amplitudes of the waves

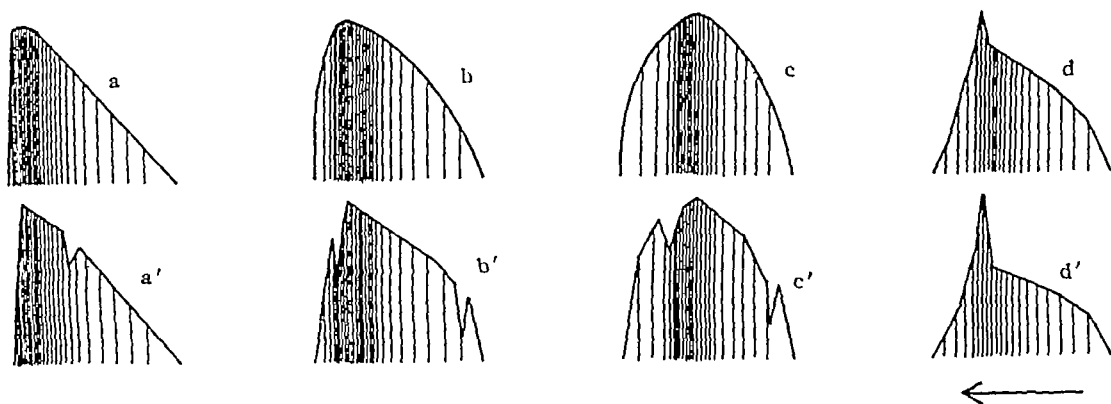


Fig 9 Diagrammatic representation of the various types of waves and the vibrations imposed on them by the phenomena which produce the heart sounds

is due to phenomena associated with the closure of the semilunar valve (Fig 8-A)

At the summit of the arch of the aorta, the waves may be seen within the mediastinal shadow From this point downward the waves in the contour of the mediastinal shadow become more distinct and clearly defined, since they are contrasted against the background of the pulmonic fields Under normal conditions the waves on the left side of the aortic shadow are more prominent than those on the right side, but in increased heart action the shadows on the right side may exceed those on the left in sharpness, distinctness, and prominence The heart size appears to bear no direct relationship to the amplitude of the aortic waves

In the examination of the same individual at different times under unchanged conditions, no significant variation in the characteristics of the waves (shape, amplitude, and distribution) for the particular individual has been found In other words, the particular type of heart action is characteristic for the individual Though posture modifies the heart shape and size slightly, the changes in the wave forms are insignificant

For comparison, kymograms taken at

does not, however, change the characteristics, and it also increases the migration of the wave and the upward movement at the apex

It is important also that the kymograms be made in a standard posture and during a definite respiratory phase, preferably in deepest inspiration This is particularly necessary, for not only does the general heart form differ in expiration and inspiration, but the kymographic waves differ in their number, form, and amplitude Thus portions of the cardiac shadow which show insignificant waves during inspiration, will during expiration, show strongly marked waves Over the ventricles, the sharp-pointed elements in inspiration give way to the rounded elements in expiration The right contour of the vascular shadow may show insignificant waves during inspiration, but during expiration definite high sharp-pointed waves appear In expiration, the waves over the left contour of the aorta have a markedly increased altitude

*Analysis of Contours*—In a kymographic examination, each chamber of the heart, as well as the aorta and its great vessels, writes on the film a wave with the features sufficiently characteristic to permit the determination of the exact part they play in



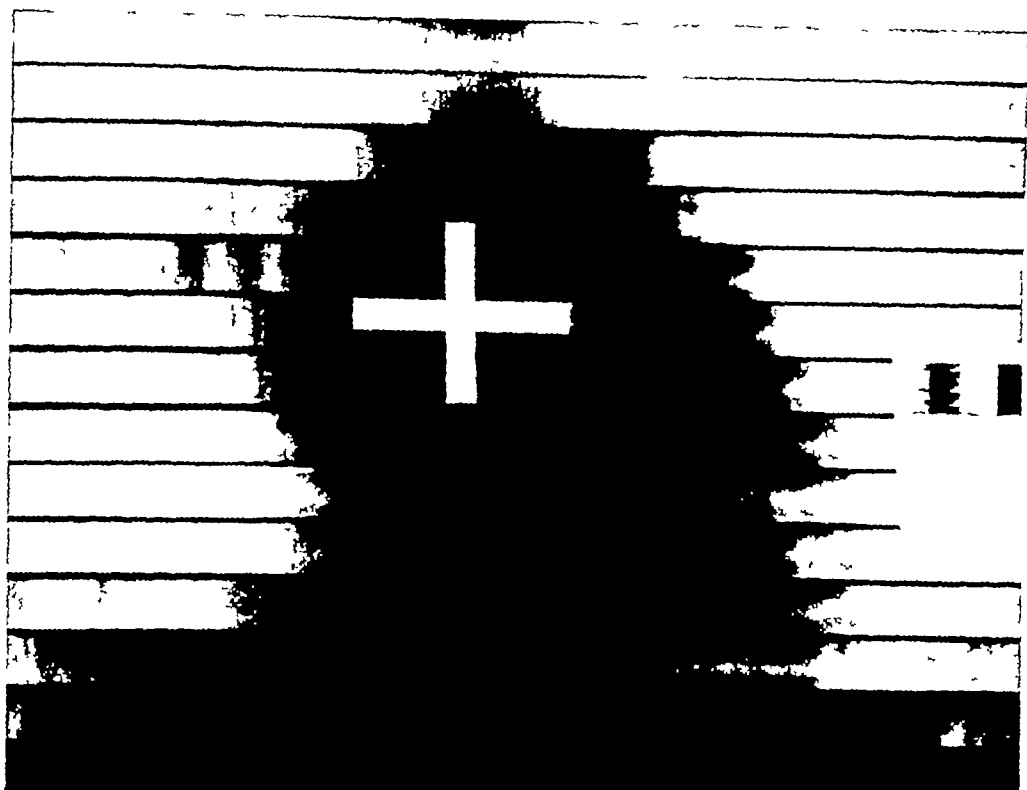


Fig 8-B In this case the sound record is placed opposite the ventricular area for correlation with the ventricular waves. The lowest and uppermost peaks of the sound record (first sound) correspond exactly to a definite notch on the systolic limb of the ventricular wave, a short period after the beginning of systole. The sound vibration is completed long before systole is finished. It would thus indicate that the first sound is accompanied by a very rapid vibration of the ventricular wall. An exactly similar condition is found in the right ventricular waves. The cross indicates the position of the stethoscope.

The complicating ventricular wave interposed between the auricular waves may exceed the auricular waves in amplitude in portions of the auricles closest to the ventricles. At the transition points between the chambers the waves of motion have always a more or less composite makeup.

*Vascular Waves*—There is a striking similarity between the pulmonary artery and aortic waves, with the difference that the peak of the aortic wave is sharp while that of the pulmonary artery is blunted or flattened. The amplitudes of the pulmonic waves are less than the aortic.

The wave produced by the aorta consists, normally, of a slow, long, descending limb (inward movement) and a sharp, steep, almost horizontal outward thrust. The point of maximum outward thrust is

attained before the completion of the ventricular systole. These waves are usually definite and clear over the entire aortic shadow. Over the ascending arch shadow, they may be complicated by a flat wave, due to motion of the superior vena cava. These are characterized by a slow rise, a serrated or domed peak, and a slow descent. In reality the dome consists of three short peaks. These are the auricular, venous and a peak which corresponds to the C wave of the pulse waves. The waves of the thoracic aorta may normally be observed through the cardiac shadow along the left side of the spine, as far as the diaphragmatic zone.

The sharp rise of the steep ascending limb of the aortic wave begins simultaneously with the beginning of the ventricular



Fig 10 Roentgen-kymograph with simultaneous roentgenphonogram By putting a straight edge on the sound record the relationship of the first and second sounds to the movement record may be determined It will be seen that there is a peak on the systolic limb of the ventricular wave which corresponds to the first sound and another peak on the beginning of the diastolic limb corresponding to the second sound

changer, twenty-four exposures of the chest were made in succession With the E K G electrodes on the patient, the making of an x-ray exposure resulted in the loss of an E K G string By changing the magnets to permanent magnets, and placing condensers in the E K G circuit, they succeeded in preserving their string, but at each exposure the record showed a blank space

They also found a drift of the string, so that at the end of six exposures, the process had to be interrupted and the string brought back on to the film From the series they obtained a set of chest roentgenograms, each one having a definite re-

lation to the E K G cycle, determined by the corresponding break in the E K G record

Knox made comparative studies of kymogram waves and electrocardiograms, but did not synchronize them

In 1913, Becker reported work similar to that of the Groedels Becker's contribution to the problem lies in his having applied the kymographic principle practically and also in the successful application of the simultaneous E K G record His method of eliminating the x-ray interference with the E K G consisted in applying the Groedels' method of minimizing the

the formation of the heart silhouette. Further, the transition points between the various contours may be placed with greater accuracy than is possible in the ordinary roentgenogram.

Kymographic studies indicate that it is necessary to revise our ideas regarding the component elements of the cardiac contours. In the ordinary roentgenogram of a normal heart, the right cardiac contour in most instances under normal conditions appears to be a simple continuous curve. The kymogram permits the division of this contour into two and in certain hearts into three parts—one formed by the right ventricle, one by the right auricle, and one by the left auricle. That formed by the right ventricle lies just above the diaphragm and occupies the lower third or half of the right cardiac shadow, the central portion is formed by the right auricle, and the uppermost segment in vertical hearts by the left auricle.

From the kymogram it becomes possible to determine the shape and size of the heart at any phase of its movement cycle. This is accomplished by laying off on every wave the same time value and connecting these points. Thus a series of tracings may be obtained, giving the heart shape at any particular instant from maximum systole to diastole, either of the ventricles or auricles. Such a serial analysis may be helpful in doubtful cases in differentiating normal from pathologic heart shapes.

The determination of the boundary or transition points between auricle and ventricle, auricle and pulmonary artery, or auricle and aorta may be best determined by means of caliber measurement of certain points, notably maximum diastole and maximum systole from the fixed points (bar lines). If in two neighboring bars, the maximum diastole of one wave corresponds in point of time to maximum systole of the other, the transition point is located on the line between the two bars. This method permits the more accurate measurement of the cardiac shadow. Since the boundary between the various chambers and the points of maximum and mini-

mum deviation may now be determined with accuracy, the placement of the points utilized for the measurements of the cardiac diameters becomes more precise, and the gross inaccuracies of the present-day methods of roentgenographic cardiac measurements may now be corrected.

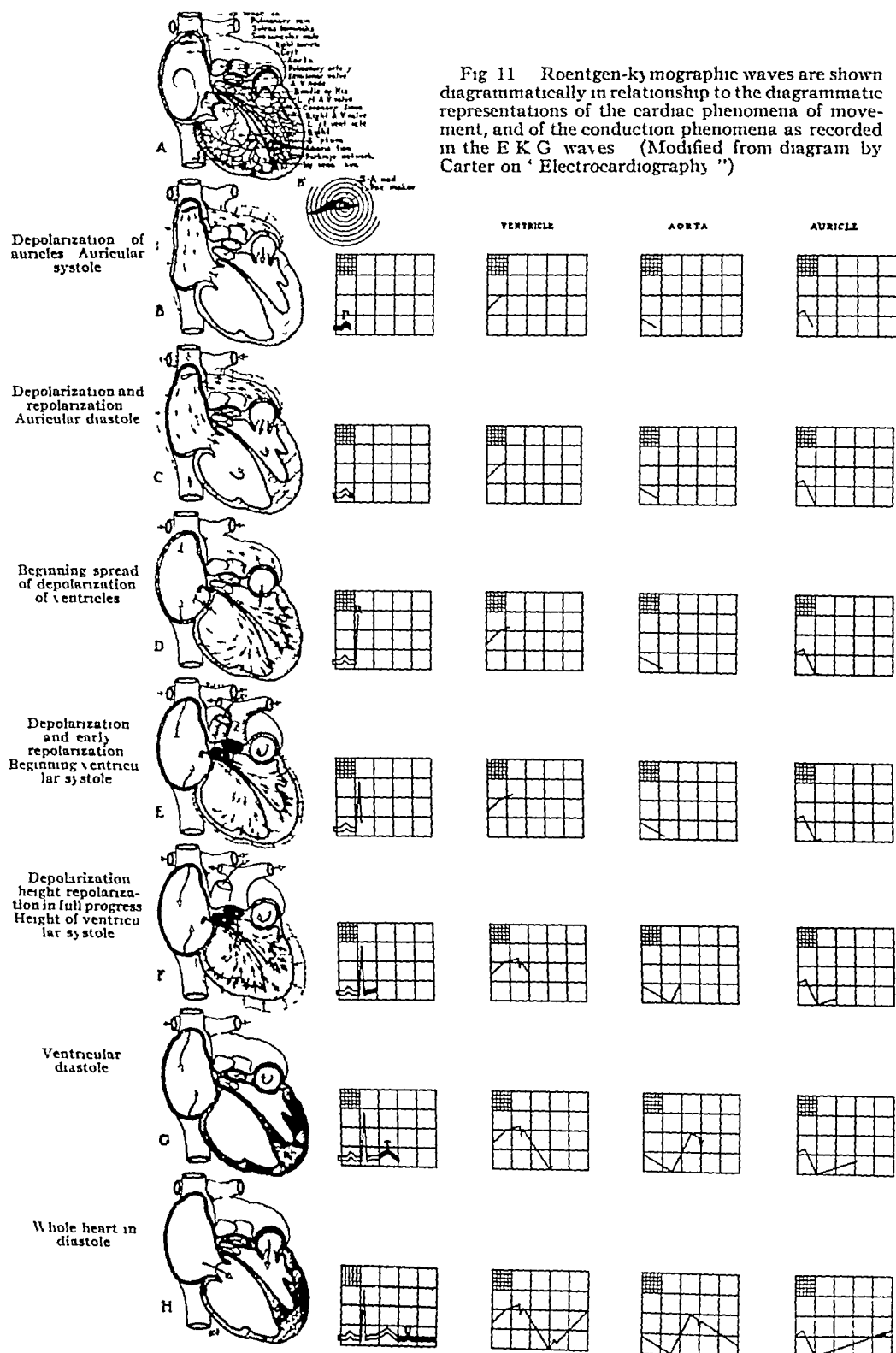
Study of the silhouettes of the heart during systole and diastole of the ventricles shows that when the ordinary standard measurements are applied there is a considerable difference in the values of the standard diameters, the transverse, long and broad, depending on the particular phases of movement depicted. The difference is particularly marked in the broad and transverse diameters, where the amplitude of the kymographic wave may be as much as 20 per cent of the left transverse diameter. A transverse measurement, as taken from the ordinary roentgenogram, may err to the extent of over two centimeters, depending upon the particular phase of contraction in which the heart is depicted.

The method permits the analysis of cardiac movement. With a series of contours of the cardiac outline in various phases of its activity, it is possible to study the extent and direction of the movement of the various portions of the heart as well as that of the heart as a whole. A polygraphic tracing demonstrates this graphically.

*Correlation with Electrocardiography*—From the beginning of kymoroentgenographic studies, the correlation of the waves to sphygmographic and electrocardiographic records has been attempted.

Goett, in 1917, described kymographic curves obtained from the left ventricle, the right auricle, and the aorta, and synchronized these curves with radial pulse tracings. The sphygmographic tracing is, however, of little help because the exact time of the radial pulsation in relation to the heart cycle is not a fixed one.

In 1912, Theodor and Franz Groedel published the results of studies linking the electrocardiograph with the actual changes in heart contour as roentgenographically recorded. By means of a rapid plate



effect and adding a foil screen between patient and x-ray tube

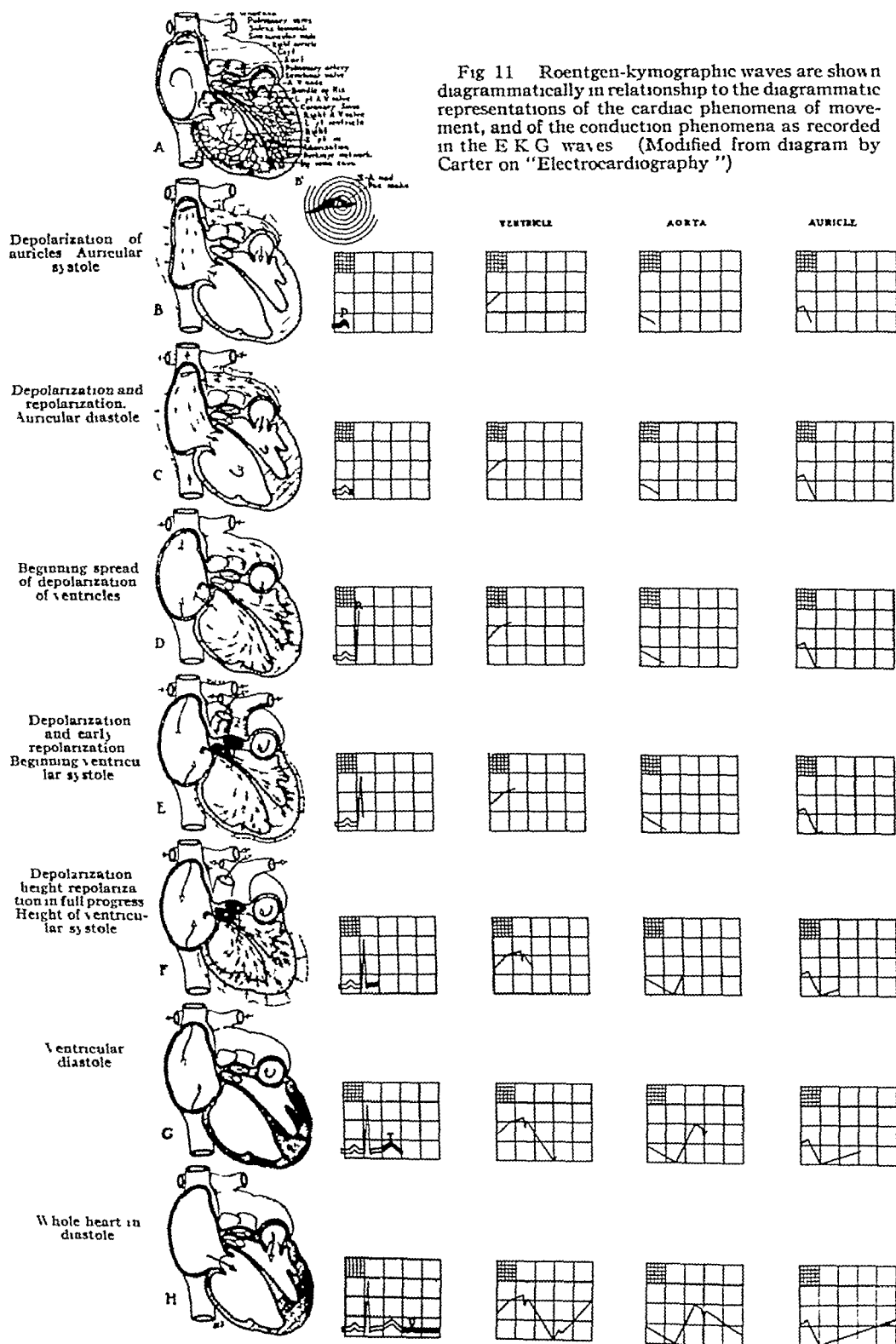
Stenstrom and Westermarck attempted to solve this problem by the use of compensators to induce into the E K G circuit additional disturbances, out of phase but of the same frequency as the undesired disturbances. Because of destructive interference it was hoped that an undistorted record would be obtained. These expectations were only imperfectly realized, however, as the E K G records of these investigators show decided irregularities during the time the x-ray tube was energized. Their compensator method is too complicated for application to routine laboratory use, involving, as it does, careful adjustment and preliminary test films for each case, since the slight disturbances can be detected only after the development of the E K G film.

Schwarzschild, working in our laboratory, found that, broadly speaking, there are two kinds of interference with the E K G. The high voltage, pulsating d c actuates the x-ray tube which leaks into the string circuit and causes the galvanometer string to move and stay out of the field, as long as the x-ray tube is energized. This effect he attributes to a static charge, and the experience of the Groedels verifies this hypothesis. Electrostatic shielding of the galvanometer string circuit from the high tension circuit overcomes this difficulty, but there remains, as Stenstrom and Westermarck also found, a 60-cycle fluctuation which cannot be attributed to the high tension circuit, since its fluctuations, in a fully rectified system such as was used in our work, have a frequency of 120 per second. The cause of these fluctuations must be sought at points in the system having a 60-cycle frequency, which fact excludes the high tension completely and leaves the low tension a c as the only possible source. It was found that a single wire connected to the live side of the 110-volt a c house circuit and brought to the vicinity of the E K G circuit, caused violent vibration in the string, even though no current flowed through the wire. These

fluctuations are, manifestly, not magnetic in nature, but electrostatic. It seems necessary, therefore, to eliminate completely all disturbances by electrostatic shielding from low tension as well as from high tension.

In order to carry out such a shielding arrangement, the electrocardiograph was set up in a room with lead-lined walls across a corridor from the x-ray tube and the high tension machinery. The E K G electrodes and the kymographic apparatus were enclosed in a metal booth equipped with an aluminum window outside of which the x-ray tube was supported (Fig 4). The E K G leads were led out of the booth in a shielded cable to a shielded conduit crossing a corridor to a lead-lined room in which the string galvanometer was set up. An automatic method of compensation was used with the string galvanometer, consisting of a condenser of 100 microfarads in series with the string. The distortions introduced in the electrocardiograph by this method of compensation have no effect on time relationships and so do not weaken the strength of any of the conclusions.

The synchronization of the E K G and the kymogram is accomplished by means of a pair of magnetic markers, one attached to the kymograph and so arranged that at each electrical impulse a trace of the stroke of the armature is left on the film, showing as a comb-like shadow in the upper right corner of the pulmonic field. The impulses are given to this marker by means of a contact mounted on the E K G time-marker, so that at every fifth-second line of the E K G, an impulse is transmitted and one of the projections is produced on the kymogram (Fig 6). The other marker is mounted in front of the E K G camera and connected by means of shielded cable to a step-down transformer, the primary of which is shunted across the primary of the x-ray transformer. Thus during the period of the exposure, the trace of this marker shows a plateau-like projection on the electrocardiogram. By means of these markers, it is thus possible to correlate within 0.03 second any point in the E K G with



the corresponding point in the kymogram. In making the simultaneous records the operator of the string galvanometer is in telephonic touch with the x-ray technician. The patient is fully instructed and, if necessary, rehearsed, as to the course of events. Then the string galvanometer is adjusted, and upon a signal, the x-ray technician is informed that all is ready as far as the E K G is concerned. He, therefore, orders the patient to hold his breath and sets the film in the kymographic apparatus in motion by means of a magnetic release. The E K G camera is started at the same time and the two records are thus taken simultaneously. The entire operation consumes only a few minutes and yields a synchronized electrocardiogram and roentgen kymogram (Fig. 6).

*Correlation* (Fig. 11) —The P wave is the auricular deflection, occupies presystole, and represents the spread of the electrical excitation-action current through the auricular musculature. The P wave is not more than 0.1 second wide and usually represents only about one-third of the duration of auricular systole. In the kymogram, the change in slope of the ventricular diastolic wave corresponds to the peak of the P wave. This change in slope or break in the diastolic wave of the kymogram is not due, as some believe, to the rotation of the heart in the process of relaxation after having been actively rotated in the opposite direction during systole.

The Q-R-S complex is the wave of ventricular excitation. It is due to an impulse which has traversed the A-V bundle, its main divisions, the right and left bundle branches, and arborizations, form the Purkinje network. In the kymogram, the point of the wave which represents the beginning of ventricular systole begins on the average 0.09 second after the beginning of the Q-R-S wave and may occur as late as 0.13 second after it.

The T wave represents the finale of ventricular systole and terminates when all parts of the ventricles first become quiescent. It represents the process of relaxation of the heart, the decline or subsidence

of the state of electrical excitability in the ventricular musculature. In other words, it represents the stage of retreat of this electrical activity, as contrasted with the stage of invasion which gives rise to the Q-R-S wave. It has a maximum duration of 0.25 second. The deepest point of the kymographic wave (end of ventricular systole and beginning ventricular filling) corresponds to the end of the T wave.

The variations from the average in the relationship between the R wave and the beginning of the systole which were observed were within 0.04 second, and the variations from the average of the time relationship of the end of the T wave from the maximum systolic position were also rarely more than 0.04 second. The time measurements on the kymogram bear an inherent experimental error of the order of 0.03 second, due to slit width. It may, therefore, be considered that the above relations are exact within this experimental error.

*Correlation with Heart Sounds* —Heart sounds have been roentgenographically recorded simultaneously with the kymogram by the following method.

A cassette containing a small x-ray film and screen is arranged to slip into a carrier firmly attached to the film carriage of the kymograph. In front of this cassette there is a lead plate with a slit. Between slit and x-ray tube there is an oscillographic unit, consisting essentially of an arm carrying a small piece of lead and capable of rotation around an axis. The rotation of the arm of the oscillograph is produced by a flow of current in an electro-magnet which attracts an armature rigidly mounted on the rotating member of the oscillograph.

Due to the relatively large inertia of the arm of the oscillograph and also to the fact that the slit must be reasonably wide in order to obtain a registration of movement during the x-ray exposure the oscillograph is actuated by currents of relatively low frequency.

The heart sounds are picked up from the chest wall by means of a stethoscope bell made of material transparent to the x-ray. The sounds are carried through a rubber

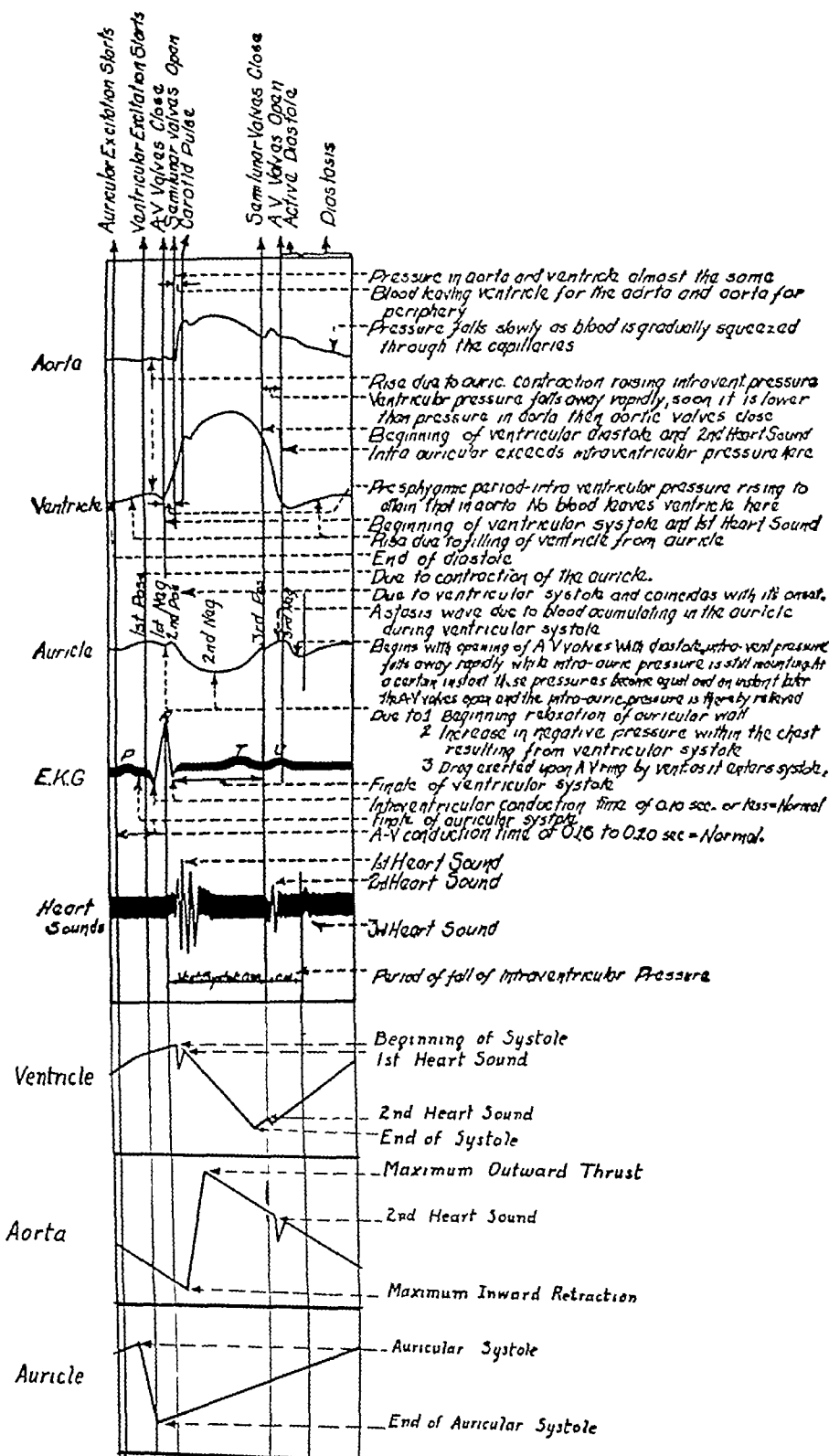


Fig 12 Diagrammatic representation of the approximate time relations of the apical heart sounds, the pressure changes, the electrocardiogram, the roentgen-kymogram, and roentgen phonogram phenomena in the right auricle, left ventricle, and aorta (Modified from diagram by Carter on "Electrocardiography")



tube into a microphone, the output of which is connected to a multistage vacuum tube amplifier. In this amplifier the heart sounds produce electric impulses corresponding to the frequency of the sounds. Because of their high frequency these impulses are not suitable for driving the oscillograph described above. In order to overcome this difficulty the output of the amplifier is led into a rectifying system and from there to the oscillograph. Thus the oscillograph unit is actuated not by the high frequency impulses of the sound itself but by a relatively slowly varying current which corresponds in contour to the intensity of the heart sound itself. At each sound the armature is attracted and the lead marker deflected in front of the slit, to return again at the end of that sound to its original position.

The developed small film shows a record of the movement of the lead marker. In the absence of sound the shadow of the marker is a straight bar with parallel sides, while with sound this shadow shows a notched edge. The depth of the notch is proportional to the intensity of the heart sound and the time duration of the notch corresponds to the duration of the heart sound (Fig. 7).

These shadow records have precisely the same time scale as the kymogram with which they are made because the film for the sound record and kymogram film move together and the exposure of both films is made by the same x-ray beam under the same conditions of excitation.

These sound records may be placed alongside any bar of the kymogram and the relationship of the heart sound and the phenomena depicted in the kymogram may be directly observed, or the waves may be compared by measurements with calipers (Figs. 8 and 9).

Measurements so made show the following relationships:

The first sound is associated with a peak or notch on the systolic limb of the ventricular wave, indicating a very rapid and small movement of the ventricle. It has no corresponding record on the aortic wave.

The second sound corresponds in time to the end of systole and is associated with a very rapid and small and inconspicuous peak arising from the deepest portion of the trough of the ventricular wave just before the beginning of diastole.

The aortic and pulmonary artery waves, however, show a conspicuous angulation in the down limb of the wave (corresponding to the inward movement of the vessel), a short distance from the peak of the maximum outward thrust. This corresponds in time to the second sound. It occurs about one-fifth of a second after the beginning of the retraction. It is apparent, therefore, that the phenomena associated with the heart sounds produce vibrations of the heart and aortic walls of sufficient intensity to be recorded on the roentgen-kymographic waves, and that kymography furnishes not only a method of recording cardiac movement, but also cardiac sounds.

#### SUMMARY

The kymographic method contributes the following information to the morphologic and physiologic study of the heart:

- 1 The actual make-up of the cardiac shadow
- 2 The shape of the heart as a whole, or any of its chambers during the various phases of movement
- 3 Size of the heart in systole and diastole or any intermediate phase
- 4 Characteristics of the movement of the heart as a whole or of its various chambers
- 5 Activity and accomplishment of the cardiac muscle
- 6 The relationship of contraction to conduction phenomena
- 7 The relationship of movement to sound phenomena

The author acknowledges his deep appreciation of the assistance rendered him by Dr. Myron Schwarzschild, physicist of the Beth Israel Hospital, in the work upon which this paper is based.

(End of Part I)

# AN ANALYSIS OF A GROUP OF PRIMARY NEWGROWTHS OF THE LUNGS, TREATED WITH DEEP X-RAY THERAPY<sup>1</sup>

By WILLIS F MANGES, M D , *Philadelphia*

THIS analysis has to do with 27 cases. The diagnosis in each case is based on the histologic study of tissue removed by means of the bronchoscope in the hands of Dr Jackson or Dr Clerf, and in one case by Dr Tucker—by surgical means or at the autopsy table. Wassermann and Kahn tests were made in all of the cases and were found to be positive in one. The histologic studies were made by Dr Crawford, pathologist at the Jefferson Hospital. There was clinical and roentgenographic evidence to support the histologic diagnosis, which in each instance was malignant. More specifically, the histologic diagnosis was carcinoma in 11, squamous-cell carcinoma in 6, carcinoma (undifferentiated) in 4, adenocarcinoma in 3, endothelioma in 1, epithelioma in 1, and one case diagnosed carcinoma from a gland removed surgically from the anterior chest wall.

Crawford and Clerf have restudied all of these cases and others in the past year and have reclassified them. As a result of this review, the histologic diagnoses of these same 27 cases are now as follows: adenoma or other benign growth in 5 (including one diagnosed elsewhere as carcinoma), carcinoma (undifferentiated) in 5, adenocarcinoma in 2, squamous-cell carcinoma in 14, carcinoma from metastatic gland in 1.

The age limits of these patients were 24 years for the youngest, 69 for the oldest, three in the twenties, four in the thirties, twelve in the forties, four in the fifties, four in the sixties. The ages of the benign group ranged from 24 to 40, of the malignant group from 38 to 69.

One case out of this group of 27 cases was treated by Dr Leo Paul Larkin, of Ithaca, New York. It is included here because the diagnostic studies were

made in the Jefferson Hospital, and it has an important bearing on subsequent events.

Of the benign group of five—two are living 9 years and 8 months since the original diagnosis and roentgen-ray treatment, one of these having had recurrence of all symptoms and a second histologic diagnosis of carcinoma in a little more than 4 years, but has remained well as result of the second roentgen-ray treatment, one is living 6 years (treated at the Jefferson Hospital, but his bronchoscopy and histologic diagnosis of carcinoma were made at the University of Pennsylvania Hospital), another is living 3 years and 7 months since treatment, and the last of the group 3 years and 3 months.

Of the group of five now considered to have carcinoma undifferentiated, one is living 4 years following her first treatments. She has had a second series, because of recurrence of hemoptysis. From recent observations it seems likely that she may die of cardiac disease, rather than of carcinoma. The original lung tumor remains evident, but considerably smaller, whereas her heart has progressively increased in size. Another of this group lived 8 months after treatment, two lived 3 months, and one we have not been able to trace.

Of the two adenocarcinoma cases, one lived 4 months, the other 6 months.

The tenure of life in the group finally diagnosed as squamous-cell carcinoma ranged as follows: one lived 2 years, 3 months, one lived 2 years, one lived 1 year, 2 months, one lived 1 year, one lived 10 months, two lived 9 months, one lived 7 months, two lived 3 months, two lived 2 months, and two have not been traced. That one patient of this group who lived 1 year after treatment had injections of lead prior to the roentgen-ray treatment. The case diagnosed from a

<sup>1</sup>Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

metastatic gland lived 2 months after treatment

The majority of the patients came for treatment only after the disease was well advanced, many of them being really too sick to receive efficient treatment. Most of them had either massive areas of density due to a tumor mass, exudate-filled lung, or collapsed lung.

The duration of symptoms prior to diagnosis varied from 2 weeks to 3 years or more. It is by no means clear in more than a few of them that the newgrowth existed at the time of the onset of symptoms, so that it is impossible to strike an accurate average duration of existence of the growth prior to treatment. However, as nearly as can be estimated, the average duration of symptoms in the benign group was 11 months, in the undifferentiated, 5 and a half months, in adenocarcinoma, 3 months, and in the squamous-cell group, 8 months.

The clinical picture is not characteristic but if one records the cases that have definite pain, cough, dyspnea, hemoptysis, and loss of weight, we find that these symptoms have a great deal of bearing on the diagnosis. In this series of 27 cases, 19 had definite pain, 25 had cough, 13 had definite dyspnea, 15, hemoptysis, 19, noticeable loss of weight. One of the squamous-cell cases had pain, another had loss of weight only. One of the undifferentiated cases had only cough and loss of weight. The other patients had three or more of the above symptoms, and, also, quite a number had all five symptoms.

It is true that cough, dyspnea, and pain, as well as loss of weight, are symptoms of other diseases, and hemoptysis, of course, has always been looked upon as possible evidence of tuberculosis, but if one resorts to the expedient of examining the sputum carefully, the presence of active tuberculosis should be eliminated with fair ease. Roentgenographically (1), this is sometimes not possible because there are cases that give somewhat the appearance of a tuberculous lesion. Hemoptysis is so important a sign in the diagnosis of primary newgrowth of the lung that one should

assume it to be necessary to exclude primary newgrowth rather than to exclude tuberculosis. Cough is but an expression of bronchial irritation and is, of course, the most constant symptom. It is easily explained in those cases that have had chronic infections over a long period of time, but in quite a few of the patients cough was the first definite evidence of the disease and the other symptoms developed rather promptly after the cough started.

The amount of radiation given has varied to a considerable extent, the aim in each instance being to deliver effective radiation in the depth of the lesion. Patients with short thoracic diameters had treatment through two portals of entry, however, most of them had treatment through three portals, one anterior, one posterior, and one lateral on the side of the lesion. One of the benign patients weighed approximately 300 pounds, so that over each of the three areas he was given a sufficient amount of radiation to produce a very marked skin reaction. The dosage was necessarily limited in some patients by reason of their inability to tolerate the treatment. As a rule, the saturation method was used.

The change in the area, as shown roentgenographically, also varied after treatment to a considerable extent. In one of the benign cases, living more than 9 years, the area of density is smaller than it was originally but is still present because of the chronic infection of bronchiectasis that still exists. Another of the benign cases, the one weighing 300 pounds, developed quite a large area of density in the field of treatment, due, I believe, to the effect of the heavy radiation. This increased area of density subsided after a period of many months. In some of the cases the tumor mass disappeared entirely but later recurred, as illustrated by the squamous-cell case that lived 2 years and 3 months after the first series of treatments. The tumor mass again disappeared after a second series, but recurred the second time and caused death. In another case, one of the undifferentiated carcinomas, the

tumor mass has gotten smaller but in other respects has not changed for more than 4 years, and the patient is still living

Summarizing the group in this respect, we have 13 in whom the area of density showed definite diminution within a month following treatment, two in whom it actually increased, two in whom it disappeared, four in whom there was no appreciable change, five in whom we have no record of the condition after radiation, and one case treated elsewhere

The important group of this series is the one made up of the five cases that are now considered to be benign, whereas formerly they had been diagnosed as malignant. In each instance, the growth may not have been malignant but certainly was in a fair way to terminate the patient's life. The fact that these patients remain well as a result of treatment emphasizes the value of the treatment and the importance of accurate diagnosis. In view of the revision in diagnosis in this group and the results of treatment, one might assume that there is a primary bronchial growth that bears somewhat the same relation to carcinoma that giant-cell tumor does to sarcoma, insofar as response to radiation therapy is concerned. Cases of this kind should not be submitted to radical surgery.

About a year ago, Vinson and Leddy (2) reported the results of roentgen-ray treatment in 32 cases. At that time, 10 of their cases were living from 15 months to 4 years after treatment. It would be extremely interesting to compare the histo-

logic character of that group with the 5 cases here reported as benign. It is entirely probable that some of them at least would be found to be similar.

It would seem quite worth while if histologic slides, roentgenograms, treatment records, and other data of all cases of primary newgrowth of the bronchi could be collected and studied by a selected group of clinicians, roentgenologists, bronchoscopists, surgeons, and pathologists, and then be reported from time to time.

#### SUMMARY

Diagnosis as a rule is not made until the lesion is well established.

Differential diagnosis of primary newgrowth of the bronchus should be made by histologic study of tissue whenever possible.

Five of a group of 27 cases are now considered benign, whereas at the time of first study the histologic diagnosis was malignant. These five are living from 3 to 9 years after roentgen-ray therapy.

There is positive evidence of prolongation of life and amelioration of symptoms in many definitely malignant cases.

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# WATER PHANTOM INTENSITY MEASUREMENTS OF HIGH VOLTAGE ROENTGEN RAYS (200 K V PEAK) AT 70 AND 80 CM SKIN-TARGET DISTANCE<sup>1</sup>

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THE question often arises in the treatment of deep-seated tumors as to the best method of delivering a predetermined dose of radiation and still do the least amount of damage to the intervening skin and normal tissue. Some radiologists advocate using a greater skin-target distance than the usual 50 cm, some the use of more filtration, higher voltages, and others a combination of the different factors. This paper deals only with a variation in the skin-target distance.

It is well known that if the skin-target distance is increased, the number of milliamperere-minutes will be increased to give an equivalent roentgen dose. This increase in milliamperere-minutes can be computed by applying the inverse square law

$$\frac{I_{80}}{I_{50}} = \frac{(80)^2}{(50)^2} = \frac{6400}{2500}$$

$$I_{50} = 2.56 I_{80}$$

where  $I_{50}$  is the intensity of 50 cm STD and  $I_{80}$  is the intensity at 80 cm STD. In the same manner

$$I_{50} = 1.96 I_{70}$$

The increase in time necessary to pro-

duce a given number of roentgen units can be somewhat reduced by a greater depth dose at 70 and 80 cm STD than at 50 cm STD. In order to determine the greater depth dose, water phantom ionization measurements were made at 70 and 80 cm STD for varying sized fields of radiation. The x-ray machine (mechanical rectification) was operated at 200 K V (peak), and 5 milliamperes, with a filtration of 0.5 mm Cu and 2 mm Al, and a half layer value of 0.80 mm Cu.

The method of making water phantom ionization measurements has been previously described (1-4).

In order to determine the efficacy of an increased skin-target distance greater than 50 cm, it is necessary to draw an anatomical chart of the patient and apply isodose charts to determine the depth dose of roentgen radiation at the different skin-target distances (4, 5).

For the purpose of making comparisons, anatomical cross-sections, all with 22 cm anteroposterior and 30 cm lateral dimensions, are shown, with indicated skin and tumor intensities for two, three, and four fields at 80 cm and four fields at 50 centimeters. Even though an anatomical chart of the cervical region is the only one shown, the same will apply to any other involved areas (7).

TABLE I — RELATIVE DEPTH INTENSITIES

Depth in water	20 cm dia field STD			16×16 cm field STD			14×14 cm field STD			10×8 cm field STD			6×8 cm field STD		
	50	70	80	50	70	80	50	70	80	50	70	80	50	70	80
Half sub	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2 cm	95	97	98	92	95	98	92	94	97	91	93	94	88	92	94
5 cm	72	70	78	69	75	78	67	70	77	64	68	70	59	63	68
7 cm	57	62	64	52	60	64	51	58	62	49	52	53	42	48	52
10 cm	39	45	47	35	43	46	33	41	44	30	36	38	26	33	38
15 cm	18	24	27	17	23	26	15	22	26	13	19	21	11	18	20
20 cm	8	13	16	7	12	16	6	11	14	4	10	13	3	10	11

<sup>1</sup>Read at the Eighteenth Annual Meeting of the Radiological Society of North America, at Atlantic City, Nov 28-Dec 1 1932

Applying two fields to a patient measuring 22 cm anteroposterior and 30 cm lateral, the tumor intensity is approximately 95 per cent, while the intensity on each skin area is 115 per cent. The tumor area will receive less radiation than each skin area. The relative skin and tumor doses are computed as follows (Fig 2)

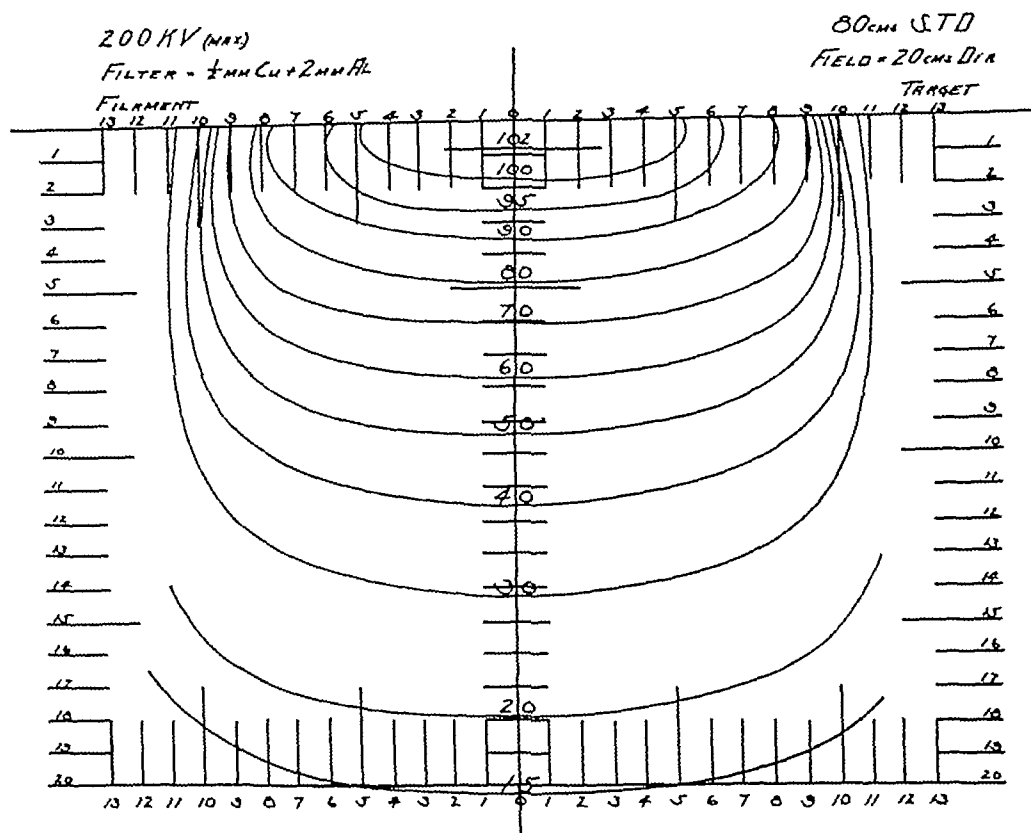


Fig 1 Isodose chart for 200 K V, 80 cm STD, 0.5 mm Cu, 2 mm Al, field 20 cm diameter

mately 95 per cent, while the intensity on each skin area is 115 per cent. The tumor area will receive less radiation than each skin area. The relative skin and tumor doses are computed as follows (Fig 2)

Tumor intensity    skin intensity    X  
100 per cent  
Substituting,  
95%    115%    X    100%  
 $115\% X = 95\% \times 100\%$   
 $X = 83\% \text{ ESD} = \text{Tumor dose when}$   
 $\text{each skin area receives } 100\% \text{ ESD}$   
(Fig 2)

Therefore, when each skin area receives 100 per cent of the predetermined erythema dose, the tumor receives 83 per cent

If the radiologist wishes to give 100 per

Skin intensity    tumor intensity    X  
100 per cent

Substituting,  
115%    95%    X    100%  
 $95\% X = 115\% \times 100\%$   
 $X = 121\% \text{ ESD} = \text{Skin dose when}$   
 $\text{tumor receives } 100\% \text{ ESD (Fig 2)}$

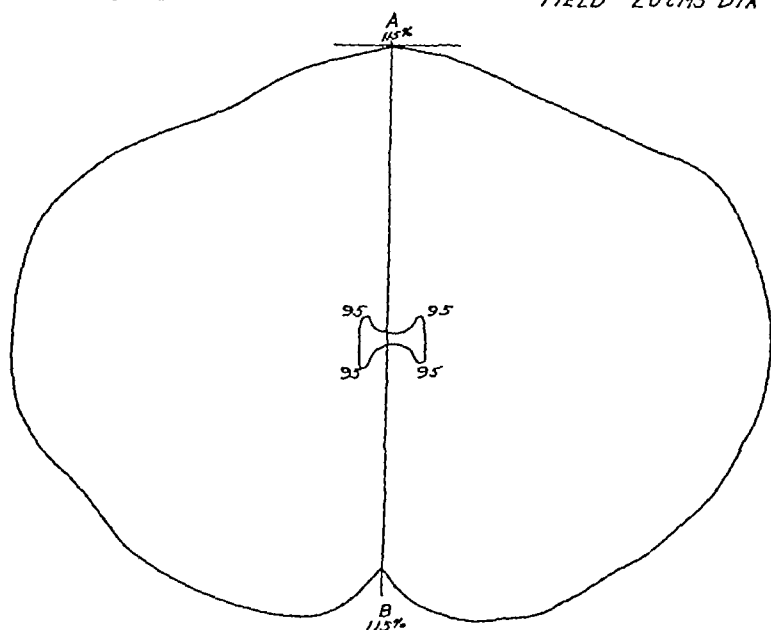
If the tumor is to receive 100 per cent predetermined dose of radiation in roentgens, it will require approximately 121 per cent of the dose to each skin area. By inspection of Figure 2, it is seen that with two fields, more radiation must be applied to each skin area than can be delivered to the tumor area.

The two oblique fields show a skin intensity of 110 per cent, while the one perpendicular field shows a skin intensity

200KV (MAX)  
80cms STD

5 MA

FILTER =  $\frac{1}{2}$ MM Cu + 2MM AL  
FIELD = 20CMS DIA



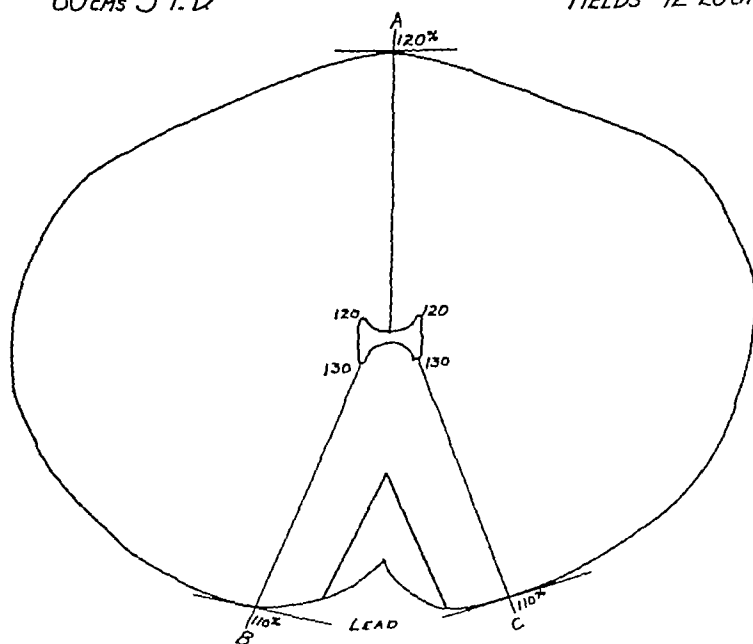
### 2 FIELD TECHNIC

Fig 2 Anatomical cross section showing (1) tumor intensity from two fields at 80 cm STD and (2) skin intensity

200KV (MAX)  
80cms S.T.D

5 MA

FILTER =  $\frac{1}{2}$ MM Cu + 2MM AL  
FIELDS = 12 \* 20CMS



### 3 FIELD TECHNIC

(1) tumor intensity from three fields at

of 120 per cent (Fig 3) The tumor intensity is approximately 125 per cent In order to give a tumor 100 per cent of an In applying two anteroposterior fields (Fig 2), it is seen that with the patient measuring 22 cm anteroposterior and 30

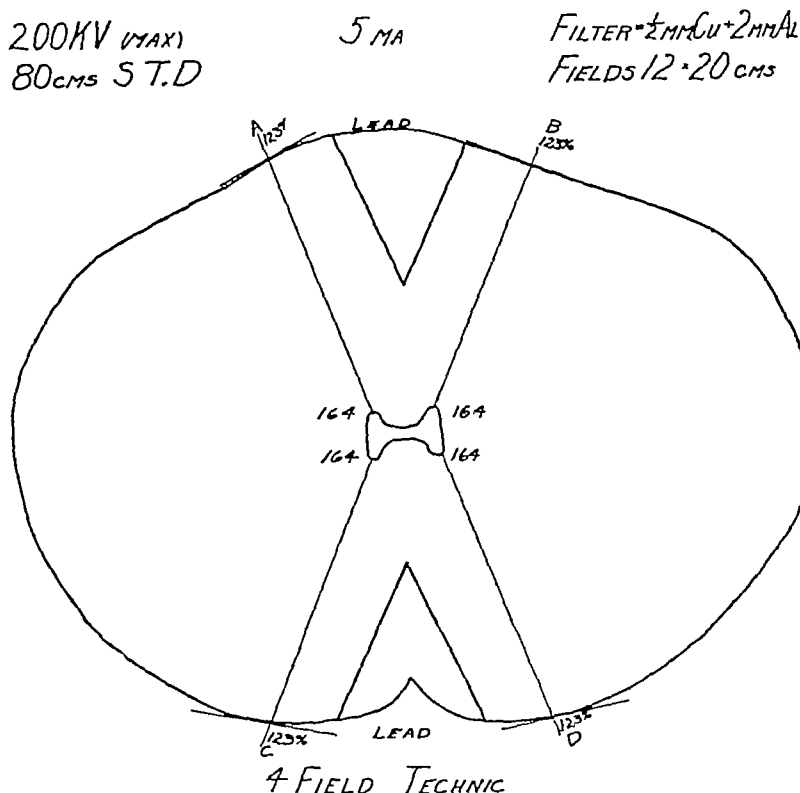


Fig 4. Anatomical cross-section showing (1) tumor intensity from four fields at 80 cm S T D and (2) skin intensity

ESD, the skin intensity of the large field, 20 cm in diameter, will receive 96 per cent ESD as,

$$\begin{array}{rcl} 120\% & 125\% & X & 100\% \\ X = 96\% & \text{ESD (Fig 3)} & & \end{array}$$

To give the tumor 100 per cent ESD, each skin area will receive 75 per cent ESD as,

$$\begin{array}{rcl} 123\% & 164\% & X & 100\% \\ X = 75\% & \text{ESD (Fig 4)} & & \end{array}$$

To give the tumor 100 per cent ESD, each skin area will receive 91 per cent ESD as,

$$\begin{array}{rcl} 107\% & 118\% & X & 100\% \\ X = 91\% & \text{(Fig 5)} & & \end{array}$$

cm lateral, the skin intensity exceeds the tumor intensity. By reducing the anteroposterior and lateral dimensions of patients, the depth intensity will increase, but at the same time the transmitted radiation will also increase so that the skin intensity remains greater than the tumor intensity.

In comparing the relationship in milliampere-minutes to two anteroposterior fields at 80 cm with four fields at 50 cm S T D, it has been shown by the inverse square law that the time required to produce the same number of roentgens per minute at 50 cm S T D is 2.56 times greater than the time at 80 cm S T D. Four fields, therefore, can be treated with a less number of milliampere-minutes at 50 cm S T D, than two fields at 80 cm S T D.

Comparing Figures 2 and 5, it is seen



that with the two-field technic at 80 cm STD, each skin area receives a larger dose than the tumor, while with the four-

distinct advantage in the use of a greater skin-target distance

If the radiologist finds that a tumor area

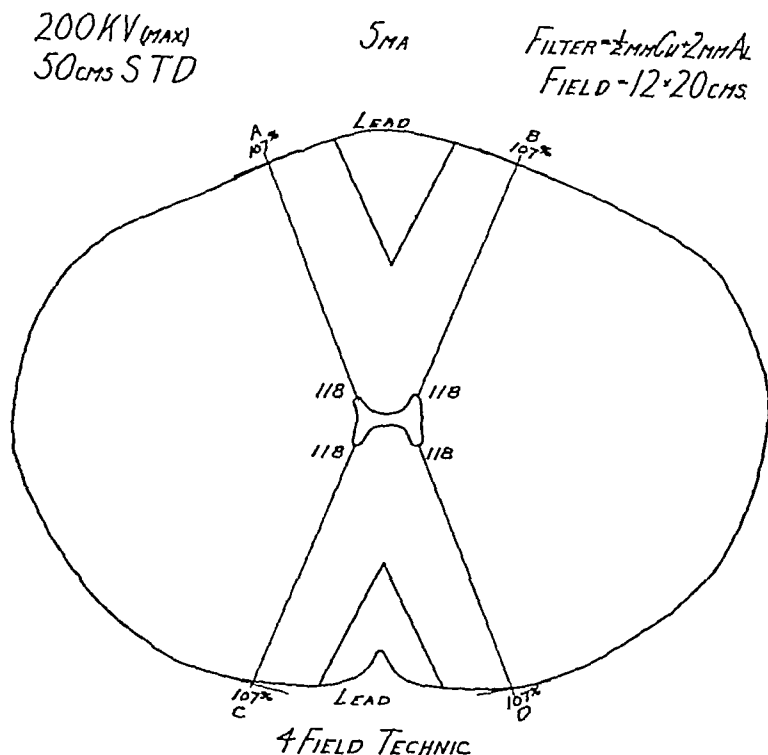


Fig 5 Anatomical cross-section showing (1) tumor intensity from four fields at 50 cm. STD and (2) skin intensity

field technic at 50 cm STD, the tumor receives a larger dose than either skin area

Comparing Figures 3 and 5, it is seen that the tumor receives more radiation than either skin area with three fields at 80 cm STD, as well as with four fields at 50 cm STD. The three-field technic at 80 cm STD gives a slightly greater tumor dose than at 50 cm STD. However, it requires approximately 18 times the number of milliamper-minute at 80 cm STD to deliver 100 per cent ESD to the tumor as compared to 50 cm STD.

Comparing the four-field technic as shown in Figures 4 and 5, it is seen that each skin area receives 75 per cent ESD when the tumor receives 100 per cent ESD at 80 cm STD. Here there is a

of a patient cannot be adequately treated without injuring the skin and intervening tissue with a four-field technic at 50 cm STD, then an increase in the skin-target distance is indicated. In such cases, time can be sacrificed to obtain a better depth dose.

If the patient has been irradiated to the point at which it is advisable to conserve intervening normal skin and tissue as far as possible and the radiologist is still desirous of further irradiating the tumor, a greater skin-target distance is preferable.

#### SUMMARY

1 By the inverse square law it is shown how the radiation changes with a variation in the skin-target distance

2 An isodose chart giving the distribution of roentgen radiation for 80 cm S T D is shown in Figure 1

3 The depth intensities of roentgen radiation from 50, 70, and 80 cm are shown in Table I

4 Isodose curves for 80 cm S T D are applied to an anatomical cross-section chart of a patient using two, three, and four fields as shown in Figures 2, 3, and 4. Isodose curves for 50 cm S T D are applied to the same anatomical chart as shown in Figure 5. Comparisons are made of the relative skin and tumor doses with accompanying changes in the intensities

5 The radiologist is justified in increasing the skin-target distance

- (a) to obtain a better depth dose when treating large patients,
- (b) to further increase the tumor dose over the skin dose in order to pre-

serve, as far as possible, the intervening skin and normal tissue

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that with the two-field technic at 80 cm STD, each skin area receives a larger dose than the tumor, while with the four-

distinct advantage in the use of a greater skin-target distance

If the radiologist finds that a tumor area

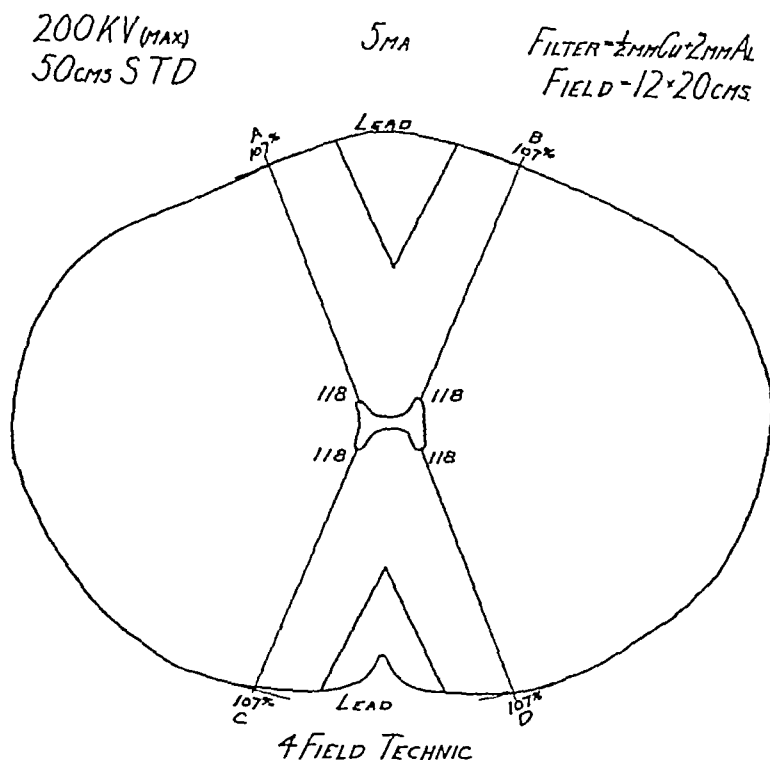


Fig 5 Anatomical cross section showing (1) tumor intensity from four fields at 50 cm STD and (2) skin intensity

field technic at 50 cm STD, the tumor receives a larger dose than either skin area

Comparing Figures 3 and 5, it is seen that the tumor receives more radiation than either skin area with three fields at 80 cm STD, as well as with four fields at 50 cm STD. The three-field technic at 80 cm STD gives a slightly greater tumor dose than at 50 cm STD. However, it requires approximately 18 times the number of milliamperes-minutes at 80 cm STD to deliver 100 per cent ESD to the tumor as compared to 50 cm STD.

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of a patient cannot be adequately treated without injuring the skin and intervening tissue with a four-field technic at 50 cm STD, then an increase in the skin-target distance is indicated. In such cases, time can be sacrificed to obtain a better depth dose.

If the patient has been irradiated to the point at which it is advisable to conserve intervening normal skin and tissue as far as possible and the radiologist is still desirous of further irradiating the tumor, a greater skin-target distance is preferable.

#### SUMMARY

1 By the inverse square law it is shown how the radiation changes with a variation in the skin-target distance

Denver, by one of us (W W W) For the third method, we studied the records of 100 children followed at the Child Research Council, Denver, since birth. The material obtained from study of the first and second groups is used in this report to check upon the findings reported in regard to the third group of 100 children followed from birth, which forms the chief basis for this study.

It is not the purpose of this paper to review the extensive literature on the subject of sinus infection or non-tuberculous chest infections, but to endeavor to determine if there is a relationship of sinus disease to chest disease as shown by the material already described. In non-tuberculous chest disease, the sinuses are often said to be responsible for lung infection. Whether the chest disease results from sinus infection or *vice versa*, or whether it is not rather a coincidence by which the whole cavity is equally infected is a problem not settled. However, it is in the sinuses and chest that the manifestations of the infections are apparent in a roentgen examination.

As stated before, our chief sources of material are the records of 100 children studied from birth. Periodic examinations are made on each child at intervals of approximately three months, consisting of detailed clinical, laboratory, and roentgenologic studies. The present ages of the children (52 boys and 48 girls) range from three months to eleven years. Table I gives the number of children and the ages at present.

TABLE I

Age	Number of cases
3 months to 6 months	7
6 months to 1 year	14
1 year to 2 years	16
2 years to 3 years	16
3 years to 4 years	8
4 years to 5 years	6
5 years to 6 years	9
6 years to 11 years	24
Total	100

The roentgenograms which had been made at intervals of three months were assembled upon a large illuminator, spe-

cially constructed to display 75 films simultaneously. Evidence of infection which began in infancy could be studied in this way and followed throughout its entire course from birth to the present date.

## DISCUSSION OF DATA

1 *The Sinuses*—In studying the sinuses of this group, the seven cases which were under six months of age are not reported, because we believe that a single roentgenologic examination is not sufficient to establish even a roentgenologic diagnosis of sinusitis in children, especially where there is no clinical evidence of such disease. At the time of delivery, the sinuses do not contain air. Aeration is gradual until they become fully aerated at from four to eight weeks (9,10). After that, decreased aeration is indicative of mucous membrane change as well as allergic or infectious changes. Hence, in our discussion the word "disease" is used rather than "infection," as "disease" implies that there may be mucous membrane changes, allergic conditions, infection, or a combination of these conditions. Sinus disease as evidenced by decreased aeration or thickening of the borders of the sinuses has been classified in this study as (1) mild, (2) moderate, and (3) severe chronic or recurrent. The term "mild disease" is used to indicate those cases in which only a few examinations show slightly decreased aeration of the sinuses. "Moderate disease" designates those changes which show a more marked decrease in aeration, occurring in a greater number of instances. By "severe chronic sinus" disease or "recurrent sinus" disease is meant those cases which show in a large number of examinations a marked decrease in aeration of one or more sinuses.

It is interesting to note that in one case followed for ten years two examinations show both maxillary sinuses with markedly thickened borders, while every other examination shows them excellently aerated. In another case followed for seven years, there has been a recurrent sinus, disease yet

# THE RELATIONSHIP OF SINUS DISEASE TO CHEST DISEASE IN CHILDREN<sup>1</sup>

By W WALTER WASSON, M D , and HAROLD D WALTZ, M D , *Denver, Colorado*

From the Child Research Council, University of Colorado School of Medicine, Denver

**N**ON-TUBERCULOUS infections of the lung, especially those outside the group comprised of foreign bodies, abscesses, and similar pathologic conditions, have occupied the interest of various investigators for some time (1,2,3) Despite this fact, there is still much to be learned about them (4,5,6) They are often erroneously classified and diagnosed as tuberculosis Pulmonary tuberculosis, on the other hand, after many years of study is fairly well understood Since the infant and young child appear to be quite susceptible to this kind of infection, it seems important to make a study of the various parts of the respiratory tract in the infant and the child and to endeavor to see if any relationship exists between infection of one part and that of another

There are at least three methods of approaching this study First, a large number of cases may be selected that have shown infection, and then a follow-up made to determine the course of the disease, second, a number of children at any given age, some of whom are evidently normal and some of whom show disease, may be studied (Either of these two methods tends, however, to give only a cross-sectional view at certain age levels) Third, a group of children may be studied periodically, starting from time of birth Under this method, the child is studied before, or at least near the time of, onset of the disease In studying the infant from birth onward, it is possible to watch for minute changes in the course and progress of non-tuberculous infections (7) If, in selecting such a series, a group is chosen not because it is particularly free or particularly susceptible to upper respiratory disease, but because it represents

an average group, we believe we will then be more successful in getting a true picture of the average child In this report we have utilized information obtained by all three methods

The respiratory tract is the only one directly open to the outside air It is composed of the accessory sinuses, mastoids, nasal and oral pharynx, larynx, trachea, bronchi, and terminal air cells, as one continuous tube with certain regional anatomical divisions It is our problem to study the relationship of infection in the sinuses and lungs which are at the opposite ends of the tract The path which infection may take from the sinuses to the lungs has had considerable study Mullin, in an experiment on rabbits, demonstrated a lymphatic connection between the sinuses and lymph nodes at the roots of the lungs (1,8) It is also possible that infection takes place by direct extension, that is, by contiguity and by continuity, by the blood, or by air column transmission Whether it is by Mullin's method (lymphatic extension) or by some other or by all, is a problem which needs much more investigation However, the point which we wish to emphasize here is that the organs of the respiratory tract constitute a single and continuous cavity

The sources of material for this study fall into three groups which were chosen to represent the three possible methods of approach For the first method, a study was made of 58 cases (some of known non-tuberculous infection) recorded and followed at the Child Research Council, Denver, and spoken of herein as the "special series" For the second method, material came from examination of the roentgen records of children seen in private practice and at Children's Hospital,

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933

tissue surrounding the lung structures and that produced by a disease process is at times difficult to determine and evaluate (13, 14). In fact, we have been unable to find in the literature accurate reports of the normal amount of connective tissue in the lungs at various age levels (15, 16). Our method has been to study these cases from birth and to arrive at a conception of average chest markings in the infant by using the subsequent examinations as criteria. In regard to connective tissue, it is well to remember that we are dealing not with acute but with chronic changes, and we are not always able to state exactly the nature of the change until a year or so after it has occurred. Chest diseases accompanying sinus disease appear to be, in our series, of a markedly chronic nature. Because of the difficulty in determining where normal growth of connective tissue ends and disease starts in the infant chest, we deem it advisable to begin our report of the presence or absence of pulmonary disease in association with upper respiratory infection at the age of two years and six months. In some cases, having once demonstrated the pathologic lesion at a later age, it is possible to return to the infant chest of two years and under and show the beginning of the inflammatory change. However, an attempt to make a diagnosis at this early age is beset with difficulties, as outlined above. This we think is one of the greatest arguments in favor of a diagnosis based upon frequent examinations at regular intervals throughout childhood, rather than one based upon a single examination or even several examinations.

TABLE III — CASES STUDIED FROM BIRTH

	Ages at last examination		
	Birth to 3 years	3 to 5 years	5 to 11 years
No disease process noted	9	7	6
Evidence of non-tuberculous infection	2	6	20
Non active tuberculosis with superimposed upper respiratory disease	0	0	2
Non-active tuberculosis, with calcification or fibrosis	1	0	4
Totals	12	13	32

The results of our study of the chests in this series are shown in Table III.

3 *Sinus Disease in Relation to Chest Disease*—In correlating the cases of sinus disease and chest disease, only those cases from two years and six months or over are reported (see above). The results of the correlation are shown in Table IV.

An analysis of Table IV shows that there are three cases followed from birth to three years which give evidence of mild sinusitis but which show no chest changes. There are no cases of mild sinusitis in either of the higher age groups. Moderate sinus disease and an absence of chest changes are noted in three of the group followed from birth to three years, two from three to five years, and six from five to eleven years. However, of 19 cases of moderate disease in the third group (five to eleven years), 13 show definite evidence of chest changes. Of the 17 cases of chronic or recurrent sinus disease with definite chest changes, two are in the first age group, five in the second, and ten in the third. The three cases of chronic or recurrent sinus disease which

TABLE IV — CASES STUDIED FROM BIRTH

Sinus infection	Ages at last examination					
	With chest changes			Without chest changes		
	Birth to 3 years	3 to 5 years	5 to 11 years	Birth to 3 years	3 to 5 years	5 to 11 years
Mild sinus disease	0	0	0	3	0	0
Moderate sinus disease	0	0	13	3	2	6
Chronic or recurrent sinus disease	2	5	10	0	3	0
Totals	2	5	23	6	5	6

on several examinations the sinuses show good aeration with clear-cut borders. For this reason we believe that it is unwise to make a diagnosis of the presence or absence of true sinus disease upon the evidence presented by one roentgen examination.

In the 93 cases from nine months to eleven years, 71 show the presence of sinus disease, the majority of which occur in the highest age group. That is, of the 34 children between the ages of five and eleven years, only two fail to show infection at some time. However, it must be borne in mind that 34 children comprise too small a group from which to generalize. The results of the study of the sinuses are given in Table II.

TABLE II—CASES STUDIED FROM BIRTH

	Ages at last examination		
	Birth to 3 years	3 to 5 years	5 to 11 years
Cases showing no disease	6	4	2
Cases showing doubtful disease	7	0	0
Cases showing slow clearing of the sinuses after birth but once cleared, then good aera- tion	2	1	0
Mild sinus disease	4	0	3
Moderate sinus disease	22	1	19
Chronic or recurrent sinus disease	4	8	10
Totals	45	14	34

2 *Chest Diseases*—Of this group of 93 cases, only those above the age of two years and six months (57 cases) are reported as to the presence or absence of non-tuberculous infections. A diagnosis of non-tuberculous infection before the age of two years and six months we believe to be extremely difficult, because it is only from the subsequent examinations that the presence of non-tuberculous pulmonary disease may be established. There may be evidences of inflammatory changes but they have not as yet established themselves sufficiently to warrant such a diagnosis. The entire group of 100 cases was, however, studied in regard to the presence of tuberculous infection. It must be remembered that the series of 100 cases followed from birth consists of apparently healthy children. Conse-

quently, the majority of these cases fall into that puzzling group which so often confronts the roentgenologist, namely, borderline cases between the normal and the diseased, between tuberculous and non-tuberculous pulmonary diseases. As a check upon our diagnosis, in these borderline cases we have made use of selected cases from our other two groups, *i.e.*, the special series, and hospital and private cases. Here we have clear-cut pictures of the infection supported by clinical evidence for comparison.

The difficulty in diagnosis of the borderline cases, especially under two years and six months, may be dependent upon several important factors of technique which have to do with correct portrayal. First, the roentgenogram must be absolutely free of movement, and those familiar with making a roentgenographic study of infants will appreciate how difficult this is even with an exposure of one-twentieth of a second, which we use as a matter of routine. Second, in children under two to three years of age, it is often difficult to obtain the desired degree of inspiration. Roentgenograms showing poor inspiration completely defeat any attempt to diagnose this type of chest disease. The increased hilar width, accentuation of peribronchial and perivascular marking, and blurring of lung detail, that are apparent on roentgenograms showing poor inspiration, so closely resemble the non-tuberculous type of chest disease that a diagnosis is frequently impossible. Third, and certainly of equal importance, is the constantly changing structure of the infant chest (11). It not only grows in size but there is a gradual change from the infant to the so-called adult type of chest markings. In our study, this change is progressive but does not conform to any certain age level. The change has been most marked, however, in the first two to three years. In short, it is imperative that the diagnostician be familiar with the changes in the infant chest that are due to natural growth (12). The borderline between a normal growth of connective

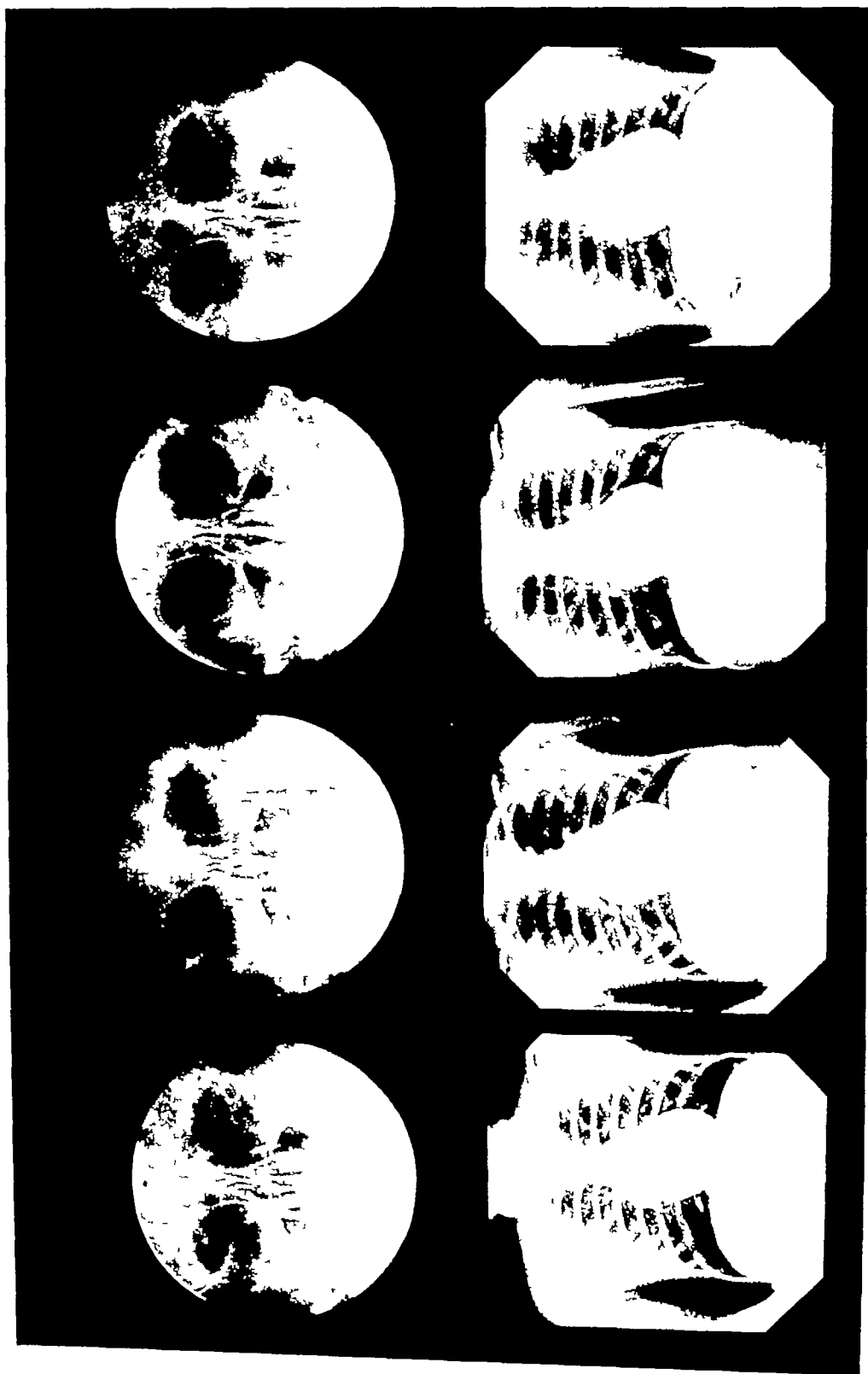


Fig 1-B

Fig 1 *Clear Sinuses and Healthy Chest* Roentgenograms selected at yearly intervals from 3 to 10 years from a series of 42 chest and sinus examinations on the same child. Note the good aeration throughout the series. Compare with Figure 2.



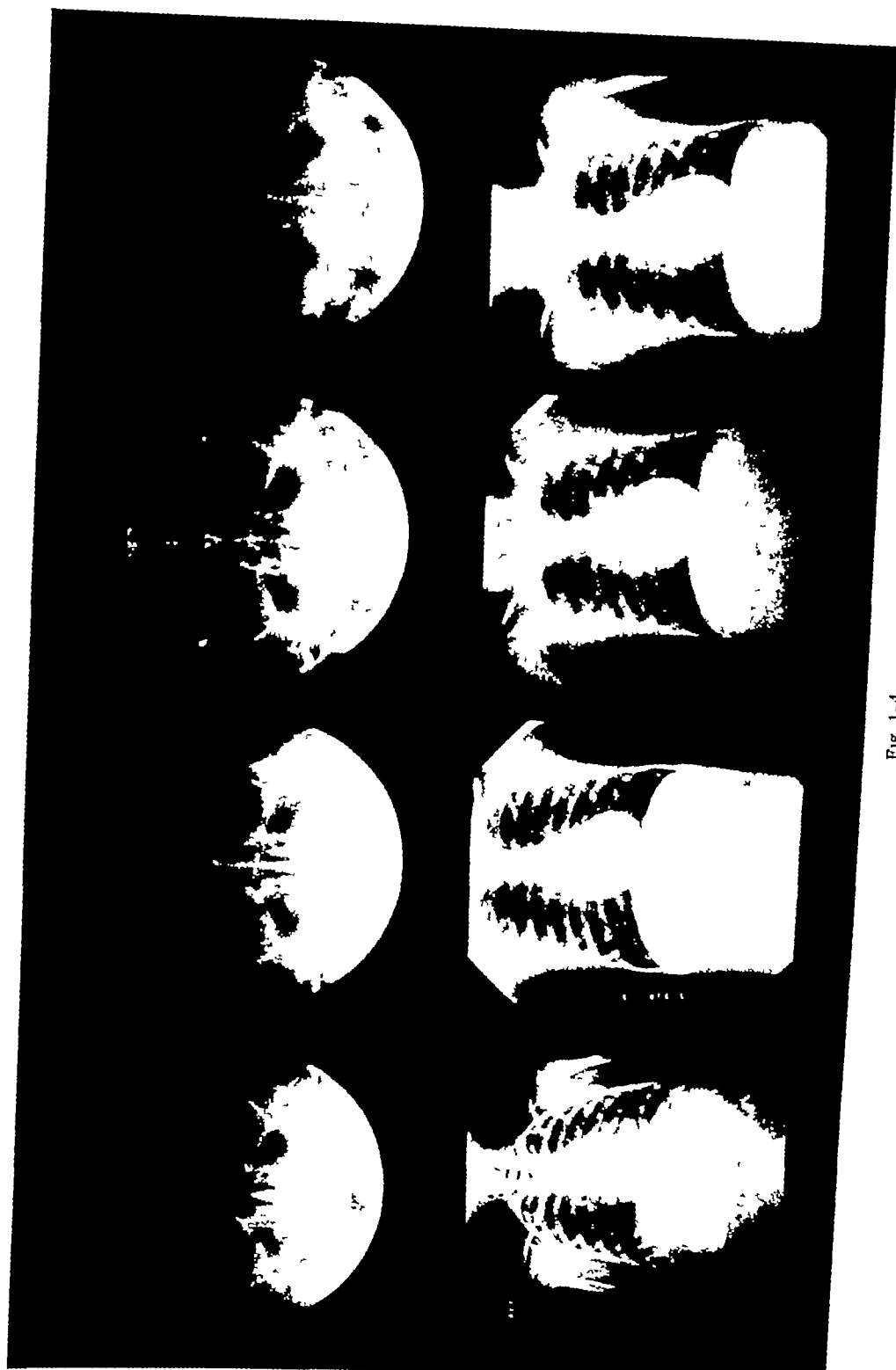


Fig 1-1

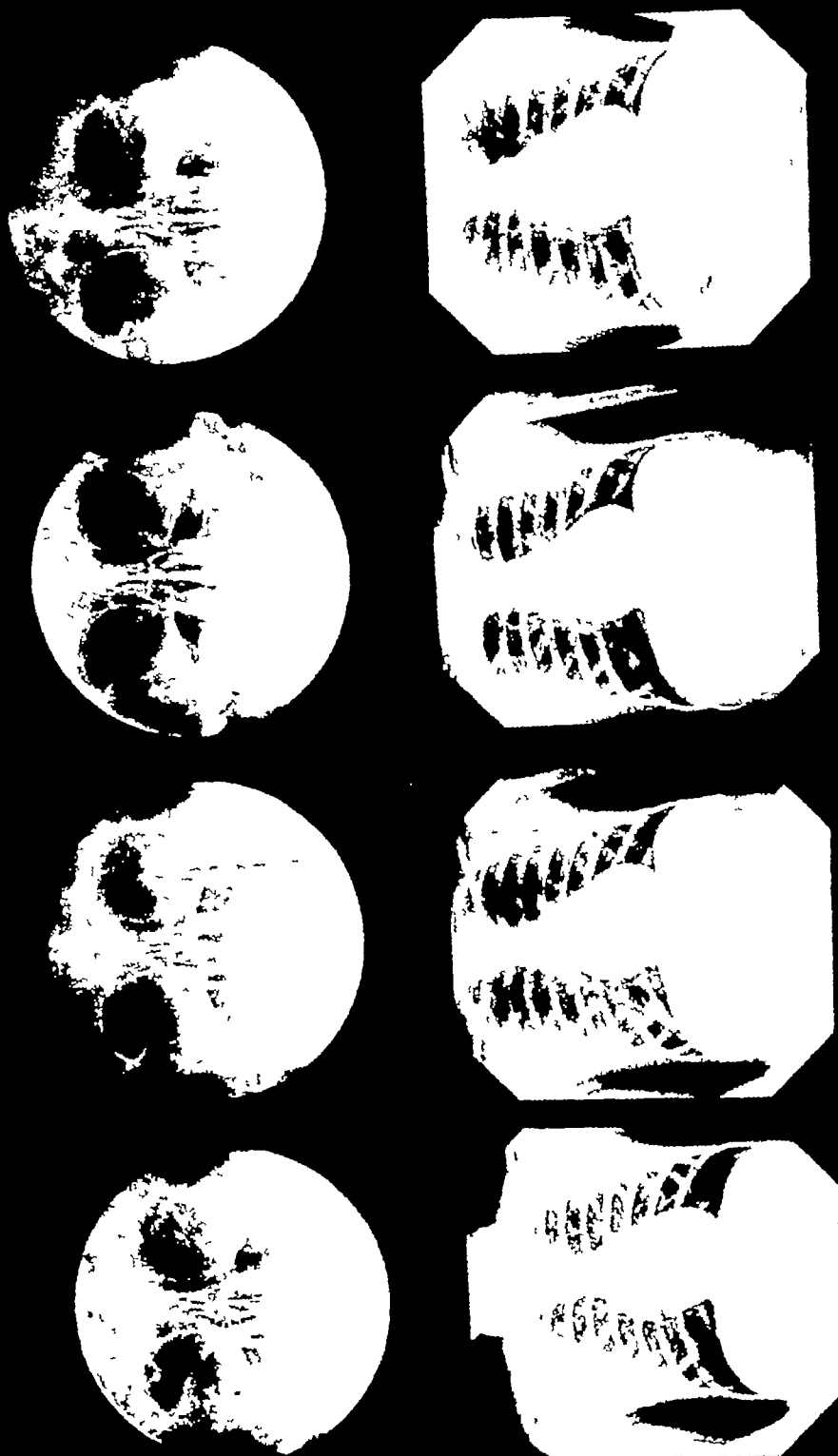


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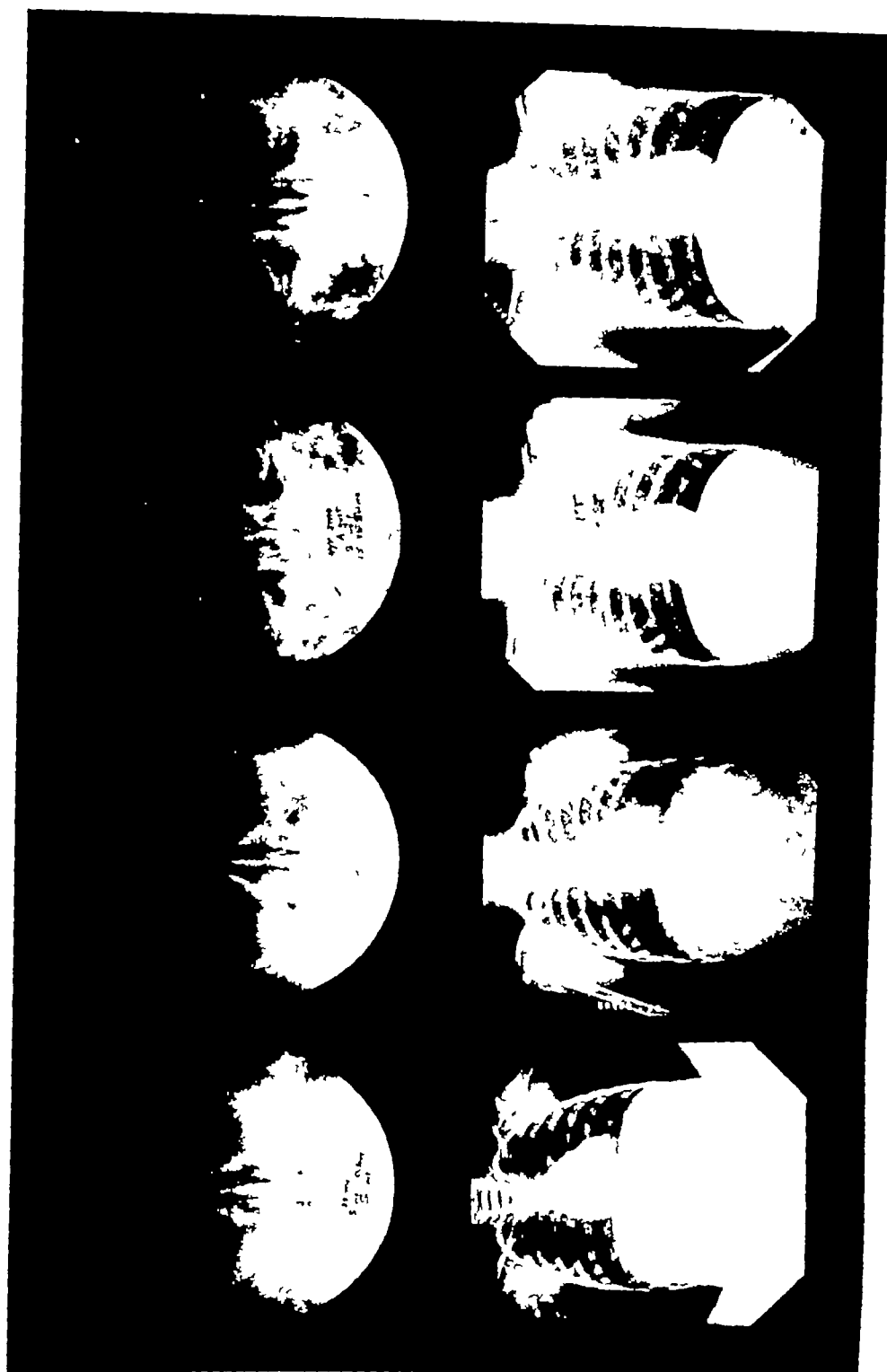


Fig 2A

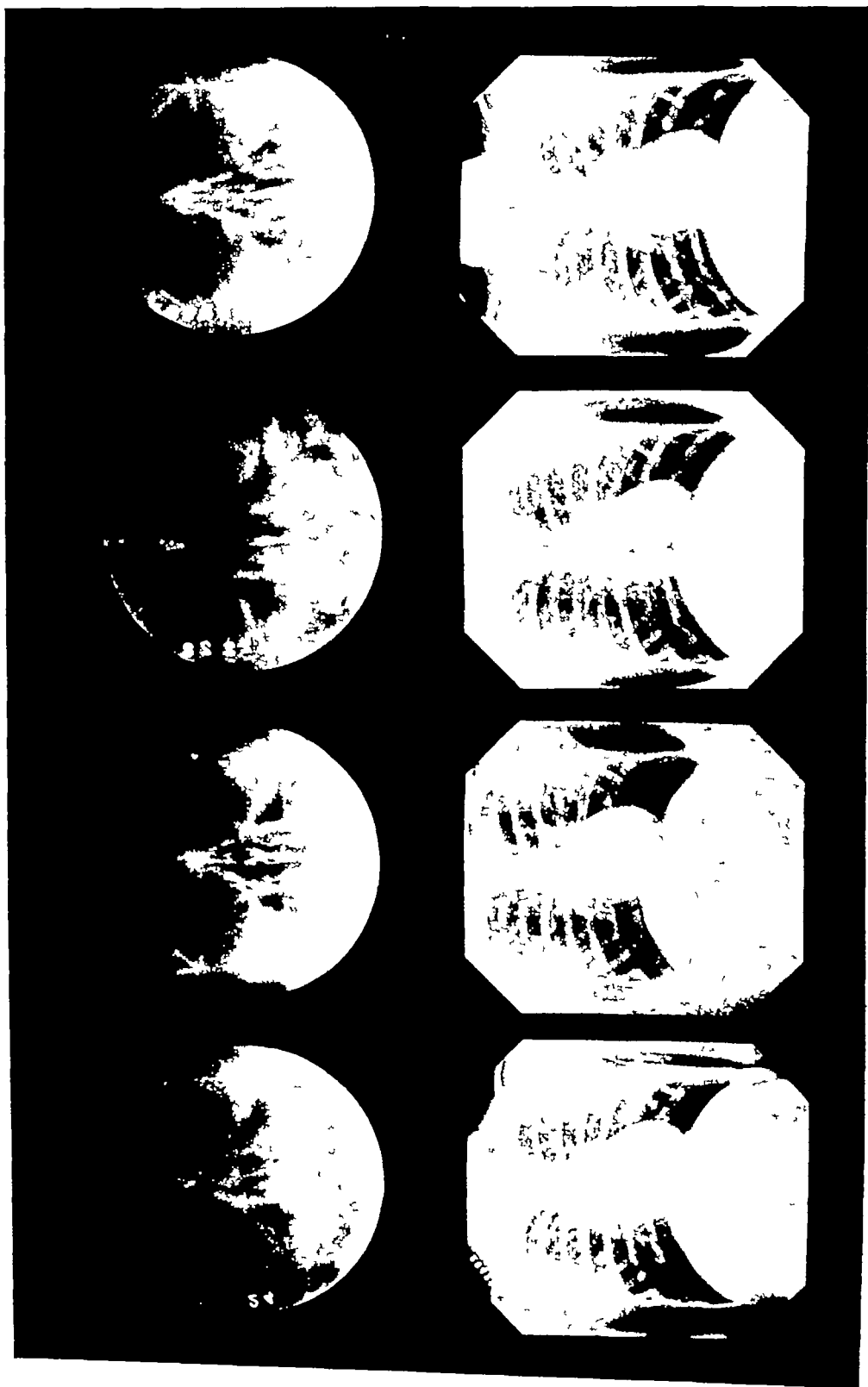


Fig 2-B

Fig 2 *Diseased Sinuses and Chest Disease* Roentgenograms selected at yearly intervals from 3 to 10 years from a series of 39 sinus and chest examinations on the same child. Note lack of aeration throughout the series, and at no time are the sinuses as clear as in the clear series. Compare with Figure 1.



Fig 3 *Healthy Chest* Enlargements of the 3- and 10 year roentgenograms as shown in Figure 1 The peribronchial and perivascular markings may be best studied with a hand lens Compare with Figure 4

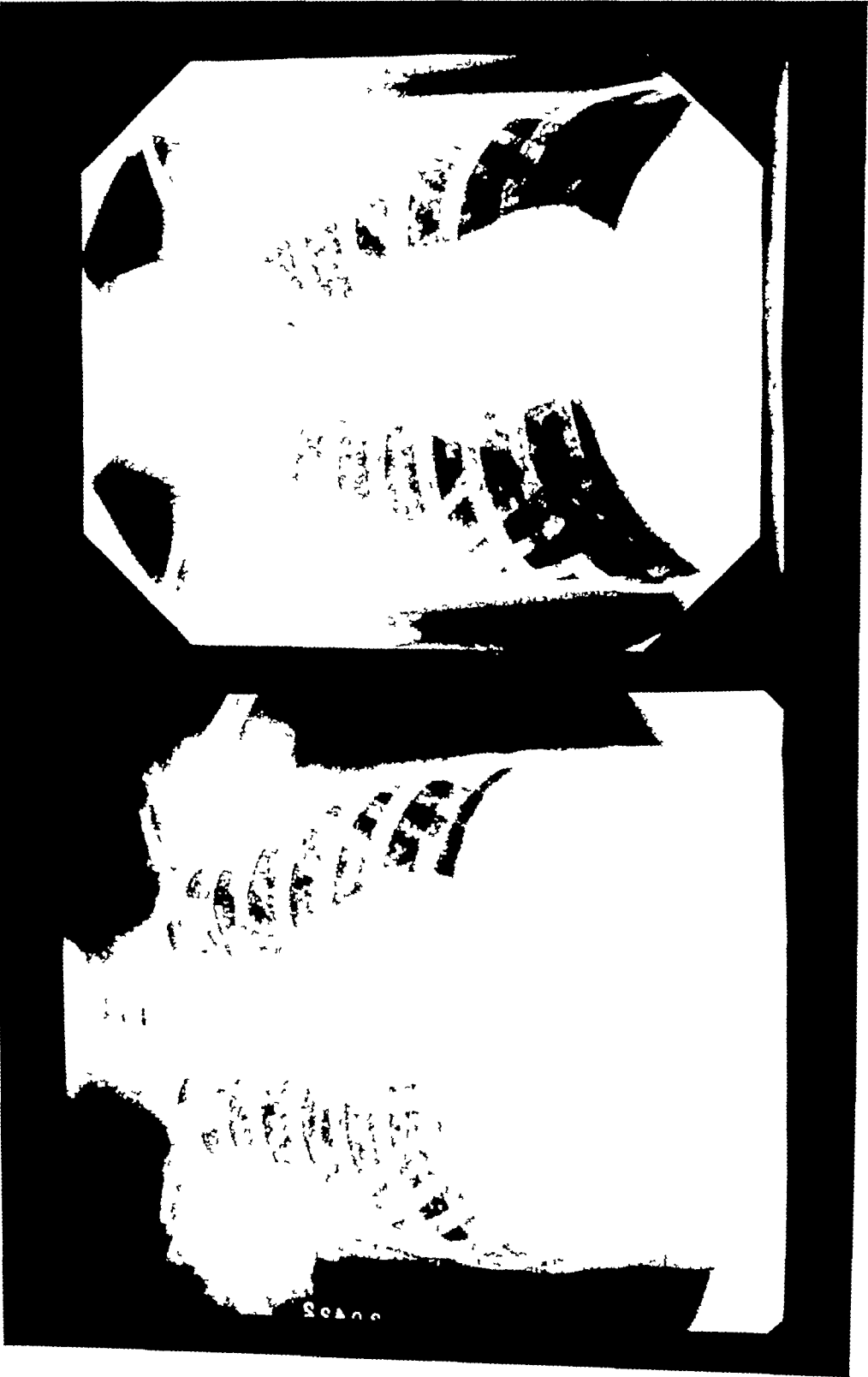


Fig 4 *Dilated Chest* Enlargements of 3- and 10-year roentgenograms as shown in Figure 2 Study with the hand lens shows increased peribronchovascular and perivascular markings characteristic of bronchiectasis disease The chest disease is apparent on the first film and extends throughout the series Compare with Figure 3

show no chest changes are all in the second age group. However, since the age of two of these cases is three years and of the other, three years and nine months, they are probably too young for positive diagnoses as yet. Further study is necessary to determine the outcome of these cases. In other words, may it not be too early to portray definitely on the roentgen film evidence of disease of the lungs in these cases?

Some relationship between the severity of the sinus disease and the chest changes is noted. If the sinus involvement is of sufficiently long standing, pathologic changes can be identified in the chest. It is possible that changes in the lungs are congestive in the beginning and that, as time goes on, they become fibrous tissue changes. Probably, also, if the chest disease is of too short duration, the chest changes are not recognized. Once this connective tissue change is established, the improvement in the sinus, acting as an indicator of respiratory infection, may mark a cessation of progress in the chest changes. However, the chest changes do not undergo resolution but remain as permanent markings of the lungs. It is to be noted that decreased aeration of the sinuses (sometimes referred to as increased density) is more readily recognized by the eye than the minute inflammatory changes along the bronchi and the vascular markings of the lungs.

#### ROENTGENOLOGIC FINDINGS OF THE CHESTS SHOWING DISEASE IN ASSOCIATION WITH SINUS DISEASE

It is not the purpose of this paper to give a detailed description of the roentgen findings of the non-tuberculous chest. In general, we have considered the characteristic changes to be a bilateral increase in width and density of the hila, together with accentuation of the perivascular and peribronchial markings. In some cases of early disease the only findings appear to be a thickening of the hila, but as these cases progress a gradual

accentuation of the trunk and linear markings appears to extend outward from the hila. Only in those advanced cases, as seen in our special series, has the parenchymal tissue appeared to be involved, as evidenced by increased interstitial connective tissue changes.

#### DIFFERENTIAL DIAGNOSIS

The differentiation of the non-tuberculous disease in children is principally concerned with incipient tuberculous infection and irritation from dust inhalation (17). This does not take into consideration those non-tuberculous conditions such as abscesses, foreign bodies, and the acute conditions which show a typical pneumonia or parenchymal involvement. The factor of dust inhalation may be considered of minor importance, since the children reported in this group all live in Denver where gas is the chief fuel and the air is not heavily laden with dust. Incipient tuberculous infection originating near the hilum may be confusing, yet it tends to be unilateral and the primary focus may be evident, or, later in the course of the disease, some calcification may be demonstrated which is not shown in the non-tuberculous infection. The usual criteria for roentgen diagnosis of a tuberculous lesion in infancy are used. However, the greatest help is obtained from serial examinations over a period of years so that the character of a particular lesion may be established. A tuberculin reaction is helpful, but in one case which showed a positive tuberculin reaction the chest was studied for eight years and the changes were of the non-tuberculous type. In our series, there are two cases of healed tuberculosis, with superimposed chest changes and marked sinus disease, but five others of non-active tuberculosis show no superimposed chest changes.

The onset of the non-tuberculous chest condition or sinus disease in infants appears to be highly insidious. At what time the condition is first manifested is not yet definitely established but it is

probably in early infancy. Under two years of age, the presence of infection of the respiratory tract is much more common in a sub-acute form than is generally believed. From our series it would appear that the process may begin very early in infancy, long before the condition is usually diagnosed by clinical methods. By the time the respiratory infection has progressed to the point at which it produces definite clinical signs and symptoms, the child is usually several years old.

By the study of a larger series of cases and by similar series followed in other cities, it should be possible to gain most valuable information concerning this group of non-tuberculous chest diseases. Tuberculosis is now well controlled by scientific investigation and education, yet such methods of study and education have not been so well applied to the non-tuberculous respiratory infections. As a result, the latter are now of perhaps greater importance than the tuberculous infections and probably handicap a greater number of our population. That this is an important disease entity is apparent when, on analysis of Table III, it is seen that, out of 57 cases, five show non-active tuberculosis, whereas 30 cases show chest and sinus disease. Again it must be noted, however, that this is too small a group from which to draw far-reaching conclusions.

Two cases are presented to illustrate the above discussion.

**Case 1**    R. L., male, 10 years of age, was born at the National Jewish Hospital for Tuberculosis. Both parents had active tuberculosis at time of the birth of the patient. Father died of tuberculosis five years later. Patient had usual childhood diseases, frequent upper respiratory infections, and chronic otitis media. He had a positive tuberculin reaction and was 12 pounds underweight.

#### ROENTGENOLOGIC FINDINGS

*Sinuses*—Since one year of age the patient had had chronic or recurrent sinus disease with exacerbations.

*Chest*—Bilateral increased width and density of the hila, with accentuation of the peribronchial and perivascular markings. No evidence of pulmonary tuberculosis on any examination.

#### DIAGNOSIS

*Clinical*—Frequent upper respiratory infections and otitis media.

*Roentgen*—Sinus disease and non-tuberculous chest disease.

**Case 2**    T. I., male, 6 years of age. Family history negative except for frequent headaches and rheumatism (?). Patient has had the usual childhood diseases and frequent upper respiratory infections. There was a negative tuberculin reaction on two occasions, frequent post-nasal discharge. He was poorly nourished and 6 pounds underweight.

#### ROENTGENOLOGIC FINDINGS

*Sinuses*—Many examinations, beginning at one year of age, show bilateral chronic or recurrent sinus disease.

*Chest*—Bilateral increased density and width of the hila, with accentuation of the perivascular and peribronchial markings, beginning at 2 years 6 months.

#### DIAGNOSIS

*Clinical*—Frequent upper respiratory infections. Underweight. Poorly nourished.

*Roentgen*—Sinus disease and non-tuberculous chest disease.

#### SUMMARY

A report is presented of a study of the roentgen findings in the sinuses and chests of (1) 100 children followed periodically since birth, (2) a "special group" of 58 children showing definite clinical evidence of infection, and (3) information drawn from material observed in private practice and at the Children's Hospital (Denver).



## CONCLUSIONS

While we do not wish to draw too many or too general conclusions from the series of children which form the chief source of material for this report, neither do we think that those drawn from large groups of single examinations are tenable. Therefore, there are certain probable conclusions which our study suggests.

Our findings would seem to indicate that there is a relationship between sinus disease and non-tuberculous chest disease.

Inasmuch as this relationship seems to exist, the term "bronchosinusitis" has been used by one of us (W W W) in previous articles to differentiate this type of condition from other acute and sub-acute general respiratory infections.

There are probably four main factors in the relationship between sinus disease and non-tuberculous chest disease.

(1) It seems likely that the onset in both *locales* is approximately coincidental, and the progress in each parallels that in the other.

(2) This chest and sinus disease appears to have an insidious onset, to be of long duration, and to show chronologic progressive changes.

(3) Increased severity of the condition in one region is associated with increased severity of the condition in the other.

(4) Cessation of sinus disease is usually accompanied by cessation of progress of non-tuberculous chest disease. This last does not necessarily mean that improvement of the sinus condition removes the causative agent for the chest infection, as the mode of extension has not yet been demonstrated.

From the above conclusions suggested

from our study, we feel that further investigation of these complex factors is advisable.

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# STANDARD ABSORPTION CURVES FOR SPECIFYING THE QUALITY OF X-RADIATION<sup>1</sup>

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## ABSTRACT

In the measurement of  $\lambda$ -rays there is a proportionality between the energy in the beam and its strength in roentgens, only for radiation of the same effective spectral distribution. In previous work, comparison with the copper and aluminum absorption curves produced by constant potential has been established as a means of equating the qualities of  $\lambda$ -ray beams excited by various voltage wave forms. Therefore, a set of standard absorption curves is set up for copper up to 180 K V (constant) and aluminum up to 110 K V (constant). Accurate evaluation of the wall absorption of the tubes used permits the establishment of basic absorption curves. Similar curves are given for potentials from 250 to 550 K V (constant), using a tube having 6 mm of copper filtration. The effect of wall absorption on the relative position of the absorption curves is discussed, and it is shown how a single curve may be used for a complete and adequate specification of  $\lambda$ -ray quality. This may be contrasted with all other quality specifications, none of which is adequate without auxiliary information.

## I—INTRODUCTION

NUMEROUS investigations during the past years have stressed the need for a more adequate filtration method of determining the quality of  $\lambda$ -ray beams that are excited by different potential wave forms. It is not that the methods in use—such as the half value layer—are theoretically unsound, but rather that, given alone, they are insufficient to give satisfactory correlation between radiations excited by potentials of different wave form. Furthermore, the several different methods in vogue do not express the quality of radiation in comparable terms.

It is, of course, well recognized that while the quality of an  $\lambda$ -ray beam is given accurately only by the spectral energy distribution of the radiation, it is un-

fortunately impractical for common use. Accordingly various indirect methods of quality description have been based upon the absorption properties of some metal such as copper or aluminum for the radiation in question. Since an x-ray spectrum is a function of the potential, these methods are frequently complicated by the fact that the potential used for exciting the  $\lambda$ -rays is periodically fluctuating. The "simple spectrum" is one produced by, and a function of, the instantaneous or sustained value of the exciting voltage and the target material. On the other hand, a "composite spectrum" is the resultant of the succession of instantaneous spectra produced by a periodically fluctuating potential and is, therefore, also a function of the wave form. Since the voltage wave forms applied to x-ray tubes are exceedingly varied and complicated, it is obvious that there is no direct simple relationship between the resultant composite spectra and the peak value of the exciting voltage. The absorption curve for radiation having a composite spectrum will be referred to as a "composite absorption curve" to distinguish it from the "simple absorption curve" characteristic of x-rays produced by constant potential.

Prime requisites for a satisfactory quality specification are, therefore (1) a sound theoretical relationship between observed magnitudes and the spectral distribution of the radiation, and (2) a simple method of quality correlation which is reasonably independent of the exciting voltage wave form, *i e*, a correlation between the quality of some one simple spectral distribution and that of the given composite spectral distribution. Simplicity and convenience of operation naturally dictate the choice of method only after these two requirements are satisfied.

Of the customary quality specifica-

<sup>1</sup> Presented at the First American Congress of Radiology, at Chicago, Sept 25-30, 1933

tions—(1) complete absorption curve,<sup>2,3</sup> (2) half value layer,<sup>4</sup> (3) effective wave length,<sup>5,6</sup> and (4) average wave length<sup>7</sup>—Duane's effective wave length method, requiring but two measurements, is the most convenient. This simplicity is offset, however, by the indefiniteness of the final result.<sup>8</sup> The half value layer method has a slight advantage in simplicity over the remaining methods in that it requires fewer auxiliary computations. A theoretically definite conclusion, however, is obtained only from the complete absorption curve, the others requiring further information which can be obtained only from the complete absorption curve. That the complete absorption curve method is not only adequate but has advantages not possessed by any of the others has been shown by a number of workers.<sup>9</sup> For example, Silberstein has shown<sup>10</sup> theoretically that a given x-ray spectral distribution will yield a particular copper absorption curve, and conversely, a spectral distribution which is sufficiently accurate for practical purposes may be derived from the complete copper absorption curve.

Until recently the complete copper absorption curve method has had the disadvantage of not being expressible by a single numerical magnitude. This has been removed, however, by finding that, within reasonably satisfactory limits, the complete composite absorption curve of radiation excited by the different potential wave forms in use, may be matched by the

instantaneous absorption curve of the same material for radiation excited by some definite constant potential.<sup>9</sup> It is further found<sup>11</sup> that such beams having equivalent absorption curves are, over a considerable range of initial filtration, closely alike as regards their intensity distribution in a large body of low atomic number material such as a water phantom. Since the spectral distribution of radiation excited by constant potential is perfectly reproducible, a family of simple absorption curves of constant voltage radiation should constitute a very convenient and adequate standard of reference for inferring the constant potential equivalent of any given radiation.<sup>12</sup>

It is of course obvious that two equivalent x-ray beams might be produced by voltages of very different peak values and hence one beam have shorter wave lengths not present at all in the other. However, the proved equivalence, where the peak voltages are very different, signifies that while there are some shorter wave lengths in one spectrum than in the other, they are present to a negligible extent.<sup>13</sup> As the equivalent constant voltage approaches the peak voltage it signifies that the energy in the shorter wave lengths becomes relatively greater. Thus, however, is taken care of in the specification of quality by the fact that for a given peak voltage, if the shorter wave lengths gain in importance, the equivalent voltage is correspondingly increased. For example, with x-rays produced respectively by mechanical, full wave, or Villard rectifiers operated at the same peak values, the equivalent voltage approaches respectively nearer the peak value, indicating an increasing relative

<sup>2</sup> E. A. Pohle and C. S. Wright. *RADIOLOGY*, January 1930 XIV 17-23.

<sup>3</sup> R. B. Wilsey. *RADIOLOGY*, October, 1931, XVII, 700-713.

<sup>4</sup> H. Holthusen and R. Braun. *Strahlentherapie*, 1933, XLVII 263.

<sup>5</sup> W. Duane. *Proc. Nat. Acad.*, 1927, XIII 668.

<sup>6</sup> L. S. Taylor. *Bureau of Standards Jour. Research* (R. P. 212), 1930, V, 517.

<sup>7</sup> A. Mutscheller. *RADIOLOGY*, April 1929 XII, 283-289.

<sup>8</sup> E. H. Quimby. *Am. Jour. Roentgenol. and Rad. Ther.* 1929 XXI, 64. See also Footnote 6.

<sup>9</sup> L. S. Taylor, G. Singer and C. F. Stoneburner. *Bureau of Standards Jour. Research* (R. P. 592) 1933, XI, 293. See also Footnotes 2 and 3.

<sup>10</sup> L. Silberstein. *Phil. Mag.* Ser. 7 1933 XV, 375.

<sup>11</sup> L. S. Taylor and K. L. Tucker. *Bureau of Standards Jour. Research* (R. P. 475), 1932 IX, 333.

<sup>12</sup> By "constant potential equivalent" is meant the constant potential necessary to apply to an x-ray tube to yield a simple absorption curve of the same form as the composite absorption curve in the same material for the unknown radiation in question.

<sup>13</sup> L. S. Taylor, G. Singer, and C. F. Stoneburner. *Bureau of Standards Jour. Research* (R. P. 592) 1933, XI 293. In particular see curves in Figures 8 and 9 of this paper.

TABLE I—ABSORPTION OF GENERAL X-RADIATION IN COPPER

Tube wall, 1.29 mm cerium glass

$I_0$  = Incident radiation       $I$  = Transmitted radiation      100  $I/I_0$  = Percentage Transmission

Copper Filter (mm)	100 K V		110 K V		120 K V		130 K V		140 K V		150 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
0	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00
0 14	20 4 <sub>0</sub>	1 310	22 0 <sub>4</sub>	1 344	23 8 <sub>0</sub>	1 377	25 8 <sub>2</sub>	1 412	27 6 <sub>4</sub>	1 442	30 3 <sub>8</sub>	1 482
20	15 3 <sub>4</sub>	1 187	17 8 <sub>4</sub>	1 251	19 9 <sub>2</sub>	1 299	21 8 <sub>1</sub>	1 339	23 4 <sub>2</sub>	1 370	25 6 <sub>9</sub>	1 410
25	12 8 <sub>4</sub>	1 110	15 1 <sub>8</sub>	1 181	17 3 <sub>7</sub>	1 240	19 1 <sub>9</sub>	1 283	20 8 <sub>8</sub>	1 319	22 8 <sub>8</sub>	1 359
30	11 1 <sub>4</sub>	1 047	13 1 <sub>7</sub>	1 120	15 2 <sub>4</sub>	1 183	17 0 <sub>6</sub>	1 230	18 7 <sub>1</sub>	1 267	20 5 <sub>8</sub>	1 313
40	8 78	0 943	10 2 <sub>8</sub>	1 012	12 1 <sub>2</sub>	1 084	13 7 <sub>1</sub>	1 138	15 3 <sub>7</sub>	1 187	16 9 <sub>8</sub>	1 230
50	7 15	0 854	8 50	0 924	10 0 <sub>4</sub>	1 002	11 5 <sub>7</sub>	1 063	13 0 <sub>8</sub>	1 116	14 4 <sub>3</sub>	1 159
75	4 53	0 656	5 77	0 761	7 04	0 848	8 32	0 920	9 55	0 980	10 6 <sub>8</sub>	1 029
1 00	3 08	0 489	4 13	0 616	5 18	0 714	6 35	0 803	7 41	0 870	8 43	0 926
1 50	1 77	0 248	2 42	0 384	3 13	0 496	4 00	0 602	4 86	0 687	5 75	0 760
2 00	1 03	0 013	1 60	0 210	2 06	0 314	2 73	0 436	3 38	0 529	4 13	0 616
2 50			1 02	0 009	1 46	0 164	2 00	0 301	2 50	0 398	3 12	0 494
3 00					1 09	0 037	1 48	0 170	1 93	0 286	2 49	0 396

intensity of the shorter wave lengths. Correspondingly it is found that the absorption curves indicate respectively harder composite radiations after the same initial filtration.

It is also to be expected that two beams which yield like absorption curves with a low or moderate initial filtration (up to 1.5 mm Cu at 150 K V, constant) may after a higher initial filtration furnish somewhat divergent curves—the curve for the radiation having the higher peak voltage falling above the other. By matching the curves above the point corresponding to the initial filtration, however, a new equivalent voltage may be found which specifies the radiation more closely. This is perfectly justifiable, since the radiation not passing through the filter is lost.

This specification of x-ray quality, by using the complete absorption curve, has been recommended by the X-ray Standardization Committee of the Radiological Society of North America.<sup>14</sup>

<sup>14</sup> Quotation from Par 7 of the 1933 Committee report: "For most practical purposes the quality of the x radiation may be satisfactorily specified in terms of the copper or aluminum absorption curve combined with a statement of the initial filtration. In lieu of an absorption curve, the equivalent constant potential applied to the tube terminals to yield the same curve may be stated as a single numerical magnitude. Up to 100 K V (constant) aluminum absorption curves and above 100 K V (constant) copper absorption curves shall be used to establish the equivalent potential." *RADIOLOGY*, March 1924, XXII, 289.

The main purpose, then, of the present investigation was to lay a general foundation and develop a procedure for deriving the two parameters of any absorption curve, namely, the equivalent constant potential excitation, together with the equivalent initial absorption.

## II—EXPERIMENTAL PROCEDURE AND CORRELATION OF ABSORPTION CURVES

The standard absorption curves shown here were obtained under conditions believed to be adequate for the purpose at the present time. The irradiation<sup>15</sup> was measured in roentgens per minute by means of a standard guarded field ionization chamber. The ionization current was measured by a null method,<sup>16</sup> using an electrometer and compensating system previously described. The readings were accurate within  $\pm 0.3$  per cent. Voltages applied to the tube were supplied by a kenotron rectifier of the Hull-Webster type, in which at the tube currents used the rippleage did not exceed 1 per cent.

<sup>15</sup> The term "irradiation" is used to emphasize the fact that these measurements were made in terms of the ionization produced in air. The ionization measurements can be used for "intensity" only when dealing with x-ray beams of exactly the same spectral distribution, and not with beams of different distribution.

<sup>16</sup> L. S. Taylor, Bureau of Standards Jour. Research (R. P. 306), 1931, VI, 807.

TABLE II — ABSORPTION OF GENERAL X-RADIATION IN COPPER

Tube wall, 1.78 mm. pyrex glass																			
$I_0 =$ Incident radiation				$I =$ Transmitted radiation												$100\ I/I_0 =$ Percentage transmission			
Copper Filter	(mm )	100 K V		110 K V		120 K V		130 K V		140 K V		150 K V		160 K V		170 K V		180 K V	
		Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$	Log $I/I_0$	100 $I/I_0$
0	0	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100
0.14	0	44.3	1.646	46.2	1.665	49.6	1.695	52.1	1.717	54.2	1.734	55.6	1.745	56.6	1.753	57.9	1.763	59.5	1.775
0.20	0	34.5	1.539	37.0	1.568	40.7	1.610	43.9	1.642	45.2	1.656	47.2	1.674	49.0	1.690	51.1	1.708	52.8	1.723
0.25	0	29.8	1.475	32.3	1.510	36.0	1.558	39.0	1.592	40.5	1.607	42.7	1.630	44.4	1.648	46.7	1.670	48.1	1.683
0.30	0	25.8	1.411	28.6	1.457	32.3	1.510	34.0	1.531	36.9	1.567	38.6	1.587	40.6	1.609	42.8	1.632	43.9	1.643
0.40	0	20.3	1.309	23.1	1.365	26.5	1.424	29.2	1.465	31.5	1.499	33.2	1.522	34.9	1.543	36.7	1.565	38.8	1.580
0.50	0	16.3	1.214	18.9	1.278	21.8	1.339	24.3	1.387	26.7	1.428	29.3	1.467	30.1	1.480	32.1	1.507	33.8	1.530
0.75	0	11.6	1.064	13.9	1.144	15.8	1.199	18.2	1.262	20.4	1.310	22.4	1.350	24.0	1.381	26.0	1.416	27.7	1.443
1.00	0	8.27	0.918	10.2	1.012	11.9	1.078	14.0	1.148	16.0	1.205	17.8	1.252	19.5	1.291	21.2	1.327	22.7	1.358
1.50	0	4.44	0.647	6.02	0.780	7.68	0.885	9.28	0.968	10.8	1.034	12.2	1.089	13.8	1.141	15.2	1.182	16.4	1.217
2.00	0	2.60	0.415	3.89	0.590	5.17	0.714	6.53	0.815	7.78	0.891	9.02	0.955	10.1	1.008	11.4	1.058	12.6	1.103
2.50	0					3.55	0.550	4.67	0.669	5.87	0.769	6.94	0.835	7.88	0.897	8.83	0.946	9.95	0.997
3.00	0					2.57	0.410	3.61	0.558	4.64	0.667	5.54	0.744	6.48	0.812	7.36	0.867	8.35	0.921

The average tube voltage was measured by means of a shielded high resistance voltmeter connected directly across the tube terminals<sup>17</sup> The voltages given are all average values and hence peak values are about 0.3 to 0.5 per cent higher Since the average voltage has been shown to provide a better indication than peak voltage of the tube output on voltages of different ripple,<sup>18</sup> the uncertainty of 0.2 per cent in the peak value is of no consequence During observations the tube voltage was measured and kept constant within limits of about 0.15 per cent

The x-ray tubes employed were housed in a lead box 4 × 4 × 7 feet To provide steadiness of operation the filament was heated by a storage battery, and the high voltage source supplied through a power stabilizer Fluctuation in voltage was very slow, corresponding to, and caused by, the change in power line frequency, and, since it was seldom greater than about ±0.3 per cent, was easily compensated manually

The filters were located for convenience about 50 cm from the target and 60 cm from the entrant diaphragm on the chamber This precluded the possibility of a measurable amount of scattered radiation entering the chamber To further insure this, the beam was diaphragmed down to a diameter of about 4 cm at the filters

Two types of tungsten target tube were used for the measurements—a hard glass thick-walled type for the higher excitation potentials and a soft glass thin-walled type for the lower This corresponds approximately to the voltage ranges in which such tubes are used in practice Since absorption of radiation by the walls is very different between such tubes, it is necessary that it be taken into consideration Of a number of thick pyrex tubes available we chose for the final measurements one ± 8 mm thick, about the average of the group

Table I gives the copper absorption

<sup>17</sup> L. S. Taylor Bureau of Standards Jour. Research (R. P. 217) 1930 V. 609

<sup>18</sup> L. S. Taylor G. Singer and C. F. Stoneburner Bureau of Standards Jour. Research (R. P. 491) 1932 IX. 561

values for radiation from a thin tube (in which the wall absorption is about the same as for 0.02 mm of copper) In the first column are given filter thicknesses at selected intervals In the other double

as 0.1 mm of copper) is given in Table II Below 100 K V (constant), absorption in aluminum has been recommended as a standard, hence Table III gives aluminum absorption data In making these meas-

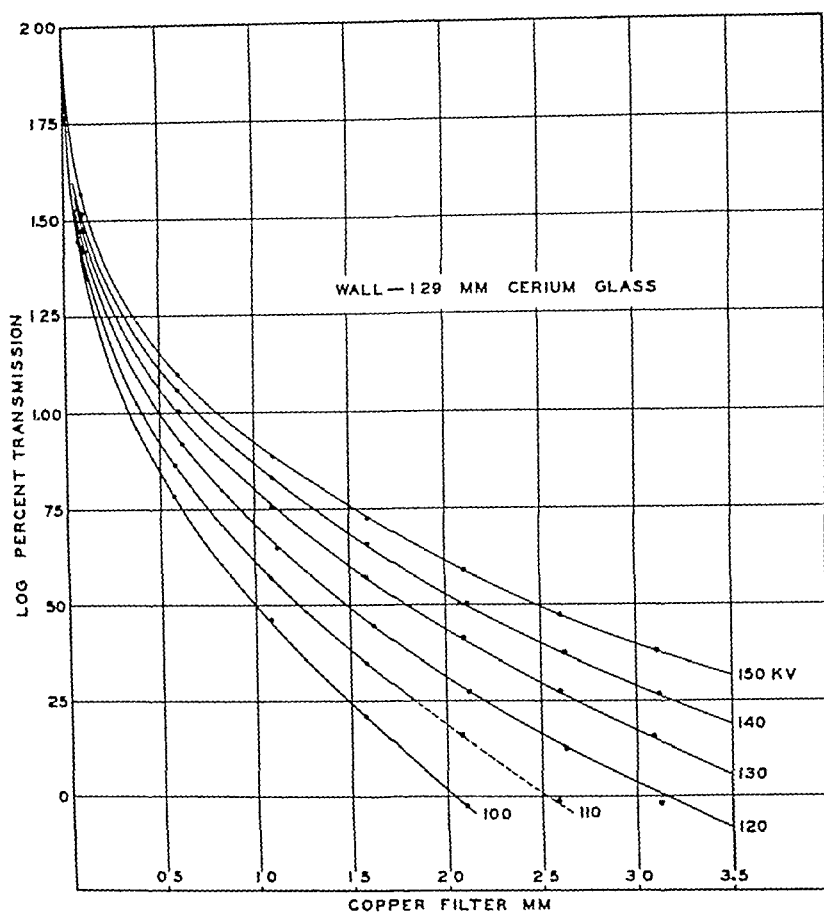


Fig 1 Copper absorption curves for thin glass tube (solid line) Plotted circles are not for the curves shown but are taken from Figure 2 and superposed to show matching by the proper shifting of each curve

columns headed by the applied tube voltage are given, respectively, the percentage transmission of the filter and its corresponding logarithm to the base 10 Where, in making the measurements, the filter thickness or applied voltage deviated appreciably from the given rounded values, corrections were applied to obtain the desired values

Similar data for the thick pyrex tube (having a wall absorption about the same

measurements, the same thin glass tube as for Table I was used

Figures 1, 2, and 3 give, respectively, for various constant potential excitations, the semilogarithmic absorption curves for copper and aluminum as plotted from Tables I, II, or III, respectively If it is assumed that, for the same excitation potential, the spectral distribution of the radiation emitted by the anticathodes of the two tubes is the same, then the difference between the

TABLE III—ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Tube wall 1.29 mm cerium glass  
 $I_0$  = Incident radiation     $I$  = Transmitted radiation     $100 I/I_0$  = Percentage transmission

Copper Filter (mm)	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
0	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00
1	32.1	1.507	33.8 <sub>1</sub>	1.530	36.0 <sub>1</sub>	1.557	38.9 <sub>6</sub>	1.590	40.3 <sub>9</sub>	1.606	42.4 <sub>2</sub>	1.628
2	19.0	1.279	20.8 <sub>1</sub>	1.318	22.0 <sub>0</sub>	1.360	25.2 <sub>1</sub>	1.403	27.2 <sub>6</sub>	1.435	29.4 <sub>6</sub>	1.468
3	12.8 <sub>5</sub>	1.109	14.4 <sub>6</sub>	1.158	16.5 <sub>1</sub>	1.218	18.4 <sub>2</sub>	1.265	20.3 <sub>1</sub>	1.309	22.3 <sub>1</sub>	1.349
4	9.3 <sub>1</sub>	0.970	10.7 <sub>1</sub>	1.033	12.6 <sub>1</sub>	1.102	14.4 <sub>1</sub>	1.159	16.2 <sub>6</sub>	1.210	18.0 <sub>2</sub>	1.256
5	7.0 <sub>6</sub>	0.845	8.44	0.926	10.0 <sub>1</sub>	1.003	11.6 <sub>6</sub>	1.064	13.4 <sub>6</sub>	1.127	15.0 <sub>2</sub>	1.177
6	5.41	0.733	6.79	0.832	8.25	0.916	9.69	0.986	11.3	1.054	12.8 <sub>1</sub>	1.110
7	4.35	0.639	5.53	0.743	6.88	0.838	8.33	0.921	9.80	0.991	11.2 <sub>1</sub>	1.050
8	3.55	0.550	4.61	0.664	5.84	0.766	7.21	0.858	8.58	0.934	9.92	0.997
10	2.44	0.387	3.42	0.534	4.38	0.642	5.44	0.736	6.63	0.822	7.85	0.895
15	1.16	0.065	1.79	0.253	2.40	0.380	3.17	0.501	4.06	0.609	4.80	0.681
20			1.00	0.000	1.40	0.147	2.01	0.303	2.60	0.415	3.17	0.501

copper absorption curves corresponding to the same potential in Figures 1 and 2 arises entirely from the difference in the absorption of the two tube walls—1.3 mm cerium glass and 4.8 mm pyrex glass.

To bring out the general information to be inferred from the absorption curves of Figures 1 to 3, and from this to correlate the curves of Figure 2 with those of Figure 1, we will take a hypothetical absorption curve  $AB$  (Fig. 4) in which  $x$  gives the thickness of copper filter, and

$$y = \log (100I/I_0) \quad (1)$$

gives the corresponding values of log percentage transmission. Here we will also assume that the incident radiation  $I_0$  is obtained from an ideal x-ray tube of zero wall thickness. In that case,  $AB$  is the basic absorption curve corresponding to the given excitation potential.

As a first case, we wish to show how, from this basic curve, the absorption curve is obtained for the same radiation after it has been modified in quality by traversing a given thickness,  $d$ , of the filter. In this case,  $I_d$ , the number of roentgens emerging from the thickness,  $d$ , becomes the incident radiation for the new curve. Against new thickness values,

$$x' = x - d \quad (2)$$

of the filter, are plotted new log percentage transmissions,

$$\begin{aligned} y' &= \log \left( 100 \frac{I}{I_d} \right) \\ &= \log \left( 100 \frac{100 \frac{I}{I_0}}{100 \frac{I_d}{I_0}} \right) \\ &= \log \left( 100 \frac{I}{I_0} \right) + \log \left( \frac{100}{100 \frac{I_d}{I_0}} \right) \\ &= y + 2 - \log \left( 100 \frac{I_d}{I_0} \right) \quad (3) \\ &= y + \text{constant} \end{aligned}$$

Thus all points on the new curve differ in position from corresponding ones on the basic curve by the same amount, that is, the new curve is obtained from the basic curve by merely shifting the origin of co-ordinates to the point  $x = d$  and  $y = - \left( 2 - \log 100 \frac{I_d}{I_0} \right)$ . That this conclusion is true may be shown by the following analysis. The 100 per cent transmission point ( $y' = 2$ ) of the new curve must lie directly above the point  $x = d$  on the basic curve, this is  $C$  in Figure 4. By assigning  $y'$  this value in Eq. 3

TABLE IV—ABSORPTION OF GENERAL X-RADIATION IN COPPER

Initial filtration Tube wall, 1.29 mm cerium glass and 0.25 mm copper  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter (mm)	100 K V		110 K V		120 K V		130 K V		140 K V		150 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
0	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00
0 15	66 5	1 823	67 3	1 828	69 8	1 844	71 8	1 856	73 5	1 866	74 5	1 872
25	53 7	1 730	56 2	1 750	58 5	1 767	61 0	1 785	62 4	1 795	63 8	1 805
5	34 2	1 534	38 0	1 580	40 7	1 609	43 7	1 640	45 7	1 660	47 1	1 673
75	23 9	1 378	27 2	1 435	29 8	1 475	33 1	1 520	35 5	1 551	36 9	1 567
1 25	13 7	1 138	15 9	1 203	18 0	1 256	20 9	1 319	23 3	1 368	25 2	1 401
1 75	8 00	0 903	10 1	1 005	11 9	1 074	14 2	1 154	16 2	1 210	18 1	1 257
2 25			6 70	0 826	8 40	0 924	10 4	1 018	12 00	1 078	13 7	1 136
2 75					6 11	0 786	7 72	0 887	9 25	0 966	10 9	1 037

$$y = \log 100 \frac{I_d}{I_0}$$

which is, compared with Eq 1, the log percentage transmission on the basic curve for a thickness  $x = d$  of the filter. This is consistent with the imposed condition that  $I_d$  should be considered the incident radiation for this particular case. If, then, we have the data for the basic absorption curve—no initial filtration—corresponding data for the radiation, after being subjected to any given initial filtration, are readily obtained by reducing the observed filter thicknesses by the initial thickness,  $d$ , and by increasing all observed log percentage transmissions by  $2 - \log \left( 100 \frac{I_d}{I_0} \right)$ .

The second case deals with the converse problem given two absorption curves of the same radiation, but subjected to different amounts of filtration, to find the difference in thickness of the initial filters. Here we are supposed to have two separate absorption curves of Figure 4— $AB$  on the  $y$  axes, and  $CB$  plotted (on transparent paper) on the  $x'y'$  axes. The second is laid over the first and shifted to that position where it is found to fit the first. The difference,  $d$ , in the two filter thicknesses, for corresponding points on the two curves, is given by the difference ( $x - x'$ ) for the point  $C$  and is the magnitude sought.

Having outlined the general procedure

we shall next inquire if like excitation potentials in the two tubes of Figures 1 and 2 produce absorption curves which are subject to the same correlation as curves  $CB$  and  $AB$  (Fig 4) just treated. In other words is the radiation from the thick wall pyrex tube (of Fig 2) of the same quality as that from the thin wall tube (of Fig 1) after passing through some unknown thickness of copper?

By taking curves of Figure 2, and fitting them, as just described, to the curves of like excitation potential in Figure 1, a very satisfactory correlation is obtained. The plotted points on the curves in Figure 1 are from the corresponding curves of Figure 2—each point on the extreme left indicating the thickness of copper (about 0.1 mm) which would make up the difference in effect of the walls of the two tubes. As may be expected, this thickness varies somewhat with the excitation potential, because the spectral absorption in glass is not the same as in copper.

From the consistency of this correlation—in which it is obvious that absorption curves corresponding to different excitation potentials do not fit—it is to be concluded that the shape of the absorption curve is characteristic of the excitation potential. On the other hand, the coordinate displacement of the given curve from that of the basic curve is characteristic of the filtration between the target and the point of measurement. Having a



family of such curves (as in Fig 1), in which the constant excitation potential varies by steps of practicable magnitude, it is clear that instead of using the complete absorption curve to specify the quality of the radiation, we may use the more convenient magnitudes excitation potential (constant) and initial filtration. Since, as shown in an earlier publication, the radiation excited by various potential wave forms, may be simply and adequately equated to that of some equivalent constant potential excitation, the quality of any given radiation may be specified by *its equivalent constant excitation potential and the initial filtration*. This initial filtration is desirably expressed in terms of the equivalent copper or aluminum.

### III—EQUIVALENT THICKNESS OF TUBE WALLS

This section is for the twofold purpose of revealing the degree of consistency obtainable from the foregoing conclusion, and of providing data from which an operator may evaluate the absorption in the wall of his own x-ray tube.

It should, of course, be borne in mind that because of the difference in atomic numbers of glass, aluminum, and copper, the equivalent thickness of one in terms of any other varies with the excitation potential of the radiation. By equivalent thickness of the tube wall, therefore, is meant the thickness of copper or aluminum

which will reduce the given incident radiation by the same fraction of its initial value as does the tube wall.

As will be seen, the equivalent thickness is not proportional to the thickness of the material. Then too, two different materials of the same equivalent thickness do not necessarily change the quality of the beam to the same degree, the change in quality varies with the exciting potential and the thickness of the absorber. However, for conditions ordinarily encountered in practice the quality change produced by equivalent thicknesses of glass, aluminum, and copper is not very different and, therefore, as we shall do below, may usually be neglected. Thus tube wall absorption may be considered as a special example of the general case set forth in Figure 4 where the wall absorption corresponds to the initial filtration,  $d$ , for the curve  $CB$ . Upon the experimental determination of

$\log \left( 100 \frac{I_d}{I_0} \right)$  it is thus possible by the methods already discussed to set up the basic absorption curve for filter thickness greater than  $d$ —but not less.

Tables IV to X, inclusive, give absorption data for various tube walls, together with the commonly used filters of copper and aluminum.

Samples used for obtaining absorption data (Tables XI and XII) of tube walls were in part cut from old tubes and in part from unused plane plates of lime and pyrex glass. The thickness of the curved pieces was measured by a spherical micrometer.

TABLE V—ABSORPTION OF GENERAL X-RADIATION IN COPPER

Initial filtration Tube wall, 1.29 mm cerium glass and 0.5 mm copper  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter (mm)	100 K V		110 K V		120 K V		130 K V		140 K V		150 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
0	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00
0.25	63.8	1.805	67.6	1.830	70.2	1.846	71.8	1.856	73.3	1.865	74.6	1.873
0.50	44.3	1.640	48.7	1.688	51.6	1.712	54.9	1.739	56.8	1.754	58.5	1.767
1.0	24.4	1.387	28.5	1.455	31.2	1.494	34.6	1.539	37.2	1.571	39.9	1.601
1.5	14.6	1.165	18.1	1.257	20.5	1.312	23.6	1.373	25.9	1.413	28.6	1.457
2.0	9.29	0.968	12.0	1.080	14.5	1.162	17.3	1.238	19.1	1.280	21.6	1.335
2.5					10.9	1.035	12.8	1.107	14.7	1.170	17.3	1.237

The wall thickness,  $D$ , of the x-ray tubes used was also measured—by the customary micrometer microscope method—focussing first on the outer surface markings, then on the inner surface markings,

used, being taken without wall correction as representing the unaltered anticathode radiation. This was considered permissible in that the copper equivalent of its wall could not be more than 0.02 mm—one-

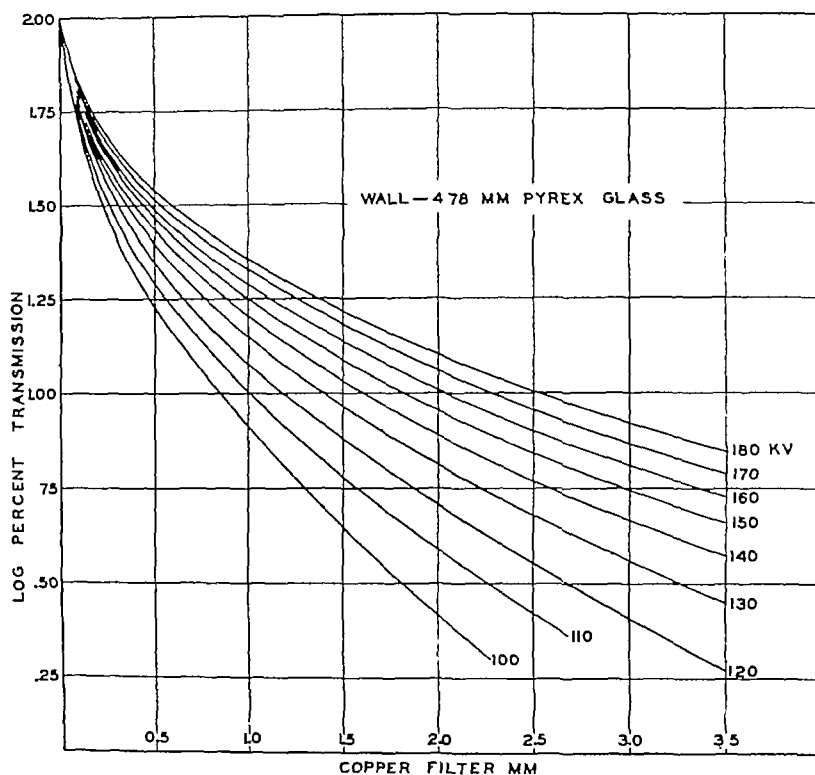


Fig 2 Copper absorption curves for thick glass tube

and observing the displacement,  $s$ , of the microscope between these two positions<sup>19</sup> This displacement multiplied by the refractive index,  $n$ , of the glass gives its thickness. The index of refraction used for lime glass was 1.52 and that for pyrex 1.48<sup>20</sup> These refractive indices were checked by thickness measurements,  $D$ , and displacement measurements,  $s$ , on pieces of the same kind from broken tubes,  $n$  being equal to  $D/s$ .

For determining the copper and aluminum absorption equivalents of pyrex glass above 100 K V, Table XI, the radiation from the cerium glass tube of Figure 1 was

sixth that found for the difference between this thin tube and the pyrex tube of Figure 2.

For determining the aluminum equivalents of lime glass, Table XII, a lime glass tube, 0.45 mm thick, was used as source of radiation. The nearly linear relation between the thicknesses of glass and of aluminum which have the same absorption at the lower thicknesses permits a fairly accurate aluminum equivalent to be assigned to this tube wall<sup>21</sup>.

An examination of Tables XI and XII will show that the variation with exciting

<sup>19</sup> The surface markings are best seen under tangential illumination.

<sup>20</sup> Their respective densities were 2.54 and 2.24.

<sup>21</sup> There may be some question as to the validity of this assumption since the measurements were all made on a radiation initially filtered with 0.45 mm of lime glass. If present at all, the error is small.



voltage of the equivalent copper or aluminum filtration of glass is not large and may be assumed as constant except for the most accurate work

The consistency of these data on tube

the radiation filtered only by the tube wall in each case. Finally, the data for all pyrex tubes are correlated with that of the cerium glass tube, following the procedure indicated by Equations 2 and 3 and taking

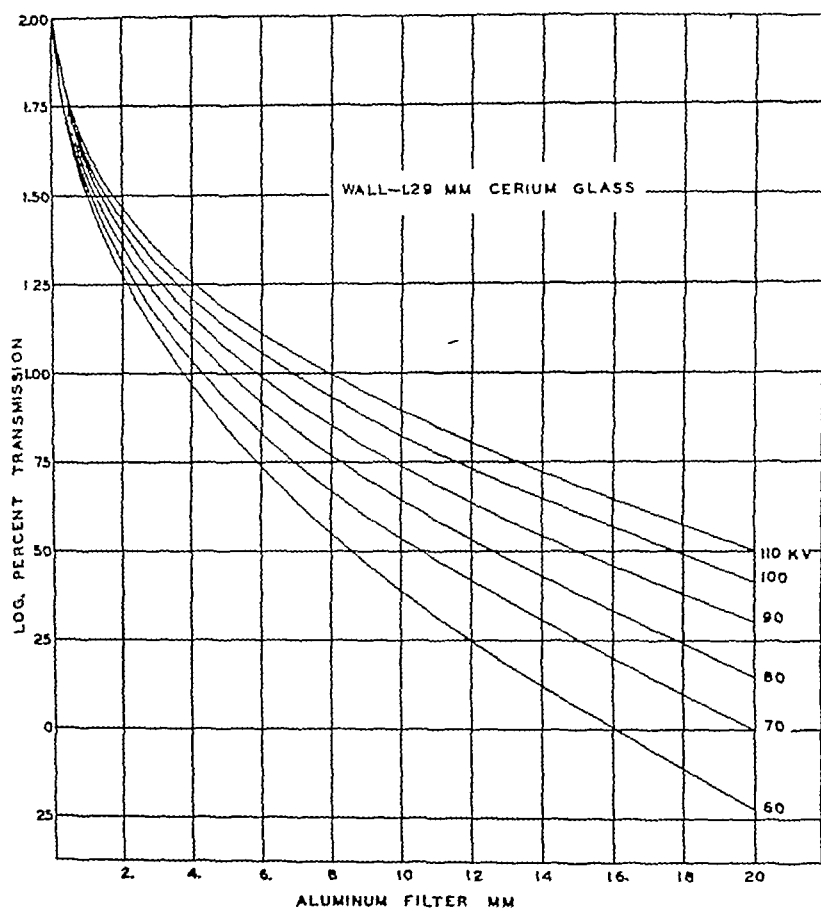


Fig 3 Aluminum absorption curves for thin glass tube

wall equivalents is strikingly illustrated in Figure 5 by the accuracy of the correlation which they furnish for the copper absorption curves of the radiation from five tubes differing both in construction and wall thickness, all excited by 150 K V (constant)

To be properly related, the data for these curves should be plotted, each on its proper co-ordinates, as fixed by the wall filtration. To avoid this multiplicity of co-ordinate systems, the data for the pyrex tubes (dashed lines) and the cerium tube (solid line) are plotted in the usual manner—taking as 100 per cent transmission,

into account here the copper equivalent of the cerium tube wall. All copper filtration values for the pyrex tube data are increased by the difference in the copper equivalents of the two tube walls—that of the cerium tube being estimated as 0.02 mm of Cu. All log per cent transmissions for the radiation from the pyrex tube are accordingly decreased by the difference in the log per cent transmission of the corresponding copper equivalents of the walls—as given in Table I. This operation should bring the absorption curve for the given pyrex tube into coincidence with that of the cerium tube. This correlation is

TABLE VI—ABSORPTION OF GENERAL X-RADIATION IN COPPER

Copper Filter		100 K V		110 K V		120 K V		130 K V		140 K V		150 K V		100 K V		170 K V		180 K V	
		Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>
(mm)		2 00		2 00		2 00		2 00		2 00		2 00		2 00		2 00		2 00	
0	15	68 6	70 5	1 836	1 848	72 1	1 858	74 2	1 870	75 9	1 880	77 3	1 888	78 3	1 894	79 3	80 2	81 0	81 4
25	50	57 3	59 6	1 758	1 775	61 7	1 790	63 5	1 803	65 1	1 820	67 9	1 832	68 9	1 838	70 0	71 4	72 8	73 4
50	75	38 8	42 2	1 580	1 625	43 9	1 643	46 8	1 267	50 4	1 702	52 5	1 720	54 1	1 730	55 1	57 6	59 0	60 0
1 25	1 75	27 7	31 3	1 442	1 495	33 3	1 522	35 9	1 556	39 6	1 597	41 9	1 622	44 0	1 643	45 4	47 3	48 6	49 5
2 25	2 75	14 9	18 6	1 172	1 269	21 3	1 330	23 7	1 376	26 7	1 426	28 8	1 459	31 3	1 496	32 6	34 2	35 6	36 4
2 75	2 75	8 70	12 00	0 940	1 079	14 4	1 157	16 7	1 223	19 2	1 284	21 1	1 325	22 9	1 360	24 4	26 3	28 5	30 0
			7 96	0 900	0 994	9 87	0 854	9 24	0 966	11 5	1 059	13 0	1 113	14 6	1 164	15 8	17 3	19 3	21 3
						7 14													

Initial filtration Tube wall, 1.29 mm pyrex glass and 0.25 mm copper

I = Transmitted radiation

I<sub>0</sub> = Incident radiation100 I/I<sub>0</sub> = Percentage transmission

TABLE VII—ABSORPTION OF GENERAL X-RADIATION IN COPPER

Copper Filter		100 K V		110 K V		120 K V		130 K V		140 K V		150 K V		100 K V		170 K V		180 K V	
		Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>	Log I/I <sub>0</sub>	100 I/I <sub>0</sub>
(mm)		2 00		2 00		2 00		2 00		2 00		2 00		2 00		2 00		2 00	
0	25	70 2	71 5	1 846	1 854	73 3	1 865	75 0	1 875	76 6	1 884	78 5	1 895	79 6	1 901	80 9	82 0	83 0	84 4
50	1 00	50 1	53 2	1 700	1 726	55 4	1 743	57 7	1 761	60 0	1 778	62 1	1 795	64 3	1 808	66 1	67 5	69 0	70 9
1 50	2 00	27 1	31 8	1 502	1 546	35 2	1 581	38 1	1 631	40 1	1 663	43 0	1 693	45 3	1 728	47 3	48 6	50 0	51 4
2 00	2 50	15 9	20 5	1 312	1 373	23 6	1 429	26 8	1 463	29 1	1 500	31 5	1 539	33 7	1 578	35 6	37 4	39 0	40 9
						16 3	1 211	19 5	1 260	21 9	1 341	23 9	1 379	26 1	1 417	28 2	29 9	31 4	33 0
						11 8	1 071	14 8	1 171	17 3	1 239	19 1	1 280	20 9	1 320	22 9	24 6	26 1	27 9

Initial filtration Tube wall 4.78 mm pyrex glass and 0.5 mm copper

I = Transmitted radiation

I<sub>0</sub> = Incident radiation100 I/I<sub>0</sub> = Percentage transmission

TABLE IX — ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Initial filtration Tube wall, 1.29 mm cerium glass and 2.0 mm aluminum  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
(mm)												
0	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00
1	67 5	1 829	69 2	1 840	72 0	1 858	72 9	1 863	74 9	1 875	76 0	1 881
2	49 1	1 691	51 8	1 714	55 1	1 741	57 0	1 756	59 6	1 775	61 3	1 787
3	36 8	1 566	40 5	1 608	43 9	1 263	45 9	1 661	49 3	1 693	51 1	1 708
4	24 4	1 454	32 6	1 514	36 0	1 556	38 3	1 584	41 6	1 619	43 8	1 642
5	22 9	1 360	26 6	1 424	30 0	1 477	33 0	1 518	36 0	1 557	38 2	1 582
6	18 7	1 271	22 2	1 345	25 5	1 406	28 5	1 455	31 5	1 499	33 7	1 528
8	12 8	1 103	16 4	1 216	19 1	1 281	21 5	1 333	24 8	1 394	26 7	1 427
13	6 10	0 785	8 60	0 935	10 5	1 020	12 6	1 099	14 9	1 174	16 3	1 213
18	3 15	0 498	4 80	0 681	6 12	0 787	7 96	0 901	9 56	0 981	10 8	1 033

TABLE X — ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Initial filtration Tube wall, 1.29 mm cerium glass and 4.0 mm aluminum  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
(mm)												
0	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00	100	2 00
1	75 0	1 875	78 3	1 894	79 8	1 902	80 4	1 905	82 6	1 917	83 3	1 921
2	57 9	1 763	63 0	1 799	65 3	1 815	67 2	1 828	69 8	1 839	71 4	1 854
3	46 6	1 668	51 3	1 710	54 4	1 736	57 8	1 762	60 5	1 782	62 2	1 794
4	38 0	1 580	42 8	1 631	46 2	1 665	50 0	1 699	53 0	1 724	55 0	1 741
6	26 1	1 417	31 7	1 501	34 7	1 540	37 7	1 577	40 9	1 612	43 6	1 639
11	12 4	1 094	16 6	1 220	19 0	1 279	22 0	1 342	25 1	1 399	26 6	1 425
16	6 42	0 807	9 28	0 968	11 1	1 046	14 0	1 145	16 5	1 218	17 6	1 245

standard conditions as the facilities permitted<sup>23</sup>

Since, as pointed out by Lauritsen,<sup>24</sup> the international definition of the roentgen permits disturbing conditions to enter at these high potentials, our measurements were made according to the revised definition of the roentgen recommended by the Radiological Society of North America Standardization Committee<sup>25</sup> Here all forms of scattered radiation are eliminated

<sup>23</sup> Only a brief description of these is given here as others will undoubtedly publish a more adequate one

<sup>24</sup> C. C. Lauritsen, *Am Jour Roentgenol and Rad Ther*, 1933, XXX, 380

<sup>25</sup> "The roentgen is the quantity of x radiation which when the secondary electrons are fully utilized and the effects of all scattered radiation avoided, produces in one cubic centimeter of atmospheric air at 0° C and 76 cm mercury pressure, such a degree of conductivity that one E S U of charge is measured under saturation conditions"

as far as possible from the measuring volume of the ionization chamber

The end of the tube containing the target and its water jacket was surrounded by a lead cap 1 inch thick in which a hole about  $\frac{3}{4}$  inch in diameter was drilled to serve as a window for passing the radiation. The filters were inserted in the beam immediately adjacent to the lead cap, and the limiting diaphragm for the ionization chamber placed 35 cm from these. This diaphragm consisted of a 2.5 cm square hole half way out the radius of a large circular lead disc 2.54 cm thick. Following the technic described by Lauritsen, the beam was cut off, without altering the amount of extraneous radiation entering the ionization chamber, by rotating this lead disc on its geometrical axis. The difference in reading of the ionization chamber magni-

indicated by the plotted points on the full line curve for the cerium tube of Figure 5

The fit is very good, and shows with what assurance the quality of constant potential radiation from a tube of given

cation of the quality of radiation furnished by a given x-ray tube

#### IV—COPPER ABSORPTION CURVES ABOVE 250 K V EXCITATION POTENTIAL

The need for specifying the quality of x-rays excited by the so-called "ultra high voltages"—250 K V and above—is particularly accentuated at present when such radiations are fast coming into use. In case of such radiation in which the wave form of the excitation potential varying as it does from the extreme furnished by the induction coil up to that of very nearly constant magnitude, it is essential that their equivalence be fixed—perhaps most suitably in terms of constant potential. The first step is to obtain the absorption curves of radiation excited by the corresponding range of constant potentials. These data were obtained through the courtesy of Dr Roscoe L Smith, of Lincoln, Nebraska, who placed for this purpose his 800 K V constant potential set at our disposal.<sup>22</sup> With this set, in which the x-ray tube with a tungsten target had a wall of 6.4 mm steel plus 13 mm of water—this initial filtration being equivalent to about 6 mm of copper—the determination of copper absorption curves in the range between 250 and 550 K V (constant) was carried out under as nearly

<sup>22</sup> We are greatly indebted to him and to Mr T R Folsom for their cordial co-operation and assistance

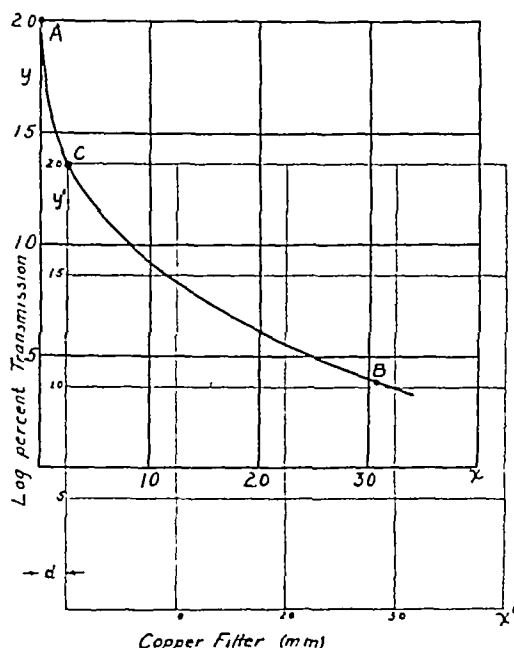


Fig. 4 Hypothetical absorption curve showing the shift of co-ordinates due to initial filtration

wall thickness can be evaluated in terms of the constant potential excitation and equivalent filtration. In other words, the equivalent thickness of the tube wall constitutes a unique and adequate speci-

TABLE VIII—ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Initial filtration Tube wall 1.29 mm cerium glass and 1.0 mm aluminum  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter (mm)	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
0	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00
1	59.2	1.772	61.5	1.789	63.6	1.803	64.9	1.813	67.4	1.829	69.3	1.841
2	40.0	1.602	42.5	1.629	45.8	1.661	47.3	1.675	50.4	1.703	52.6	1.721
3	29.1	1.464	31.8	1.503	35.1	1.545	37.0	1.569	40.1	1.603	42.5	1.628
4	21.8	1.338	24.9	1.397	28.0	1.447	29.8	1.475	33.2	1.521	35.4	1.549
5	16.8	1.226	20.4	1.310	22.9	1.360	24.9	1.397	28.0	1.448	30.3	1.482
6	13.5	1.131	16.3	1.213	19.1	1.281	21.4	1.331	24.3	1.385	26.4	1.422
7	11.1	1.043	13.6	1.134	16.2	1.210	18.5	1.268	21.2	1.327	23.4	1.369
9	7.59	0.880	10.1	1.004	12.2	1.085	14.0	1.146	16.4	1.215	18.5	1.267
14	3.61	0.557	5.28	0.723	6.66	0.824	8.15	0.911	10.0	1.001	11.3	1.054
19	1.86	0.271	2.95	0.470	3.89	0.590	5.16	0.713	6.44	0.809	7.47	0.873

TABLE IX—ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Initial filtration Tube wall, 1.29 mm cerium glass and 2.0 mm aluminum  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
(mm )												
0	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00
1	67.5	1.829	69.2	1.840	72.0	1.858	72.9	1.863	74.9	1.875	76.0	1.881
2	49.1	1.691	51.8	1.714	55.1	1.741	57.0	1.756	59.6	1.775	61.3	1.787
3	36.8	1.566	40.5	1.608	43.9	1.263	45.9	1.661	49.3	1.693	51.1	1.708
4	24.4	1.454	32.6	1.514	36.0	1.556	38.3	1.584	41.6	1.619	43.8	1.642
5	22.9	1.360	26.6	1.424	30.0	1.477	33.0	1.518	36.0	1.557	38.2	1.582
6	18.7	1.271	22.2	1.345	25.5	1.406	28.5	1.455	31.5	1.499	33.7	1.528
8	12.8	1.103	16.4	1.216	19.1	1.281	21.5	1.333	24.8	1.394	26.7	1.427
13	6.10	0.785	8.60	0.935	10.5	1.020	12.6	1.099	14.9	1.174	16.3	1.213
18	3.15	0.498	4.80	0.681	6.12	0.787	7.96	0.901	9.56	0.981	10.8	1.033

TABLE X—ABSORPTION OF GENERAL X-RADIATION IN ALUMINUM

Initial filtration Tube wall, 1.29 mm cerium glass and 4.0 mm aluminum  
 $I_0$  = Incident radiation  $I$  = Transmitted radiation  $100 I/I_0$  = Percentage transmission

Copper Filter	60 K V		70 K V		80 K V		90 K V		100 K V		110 K V	
	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$	100 $I/I_0$	Log 100 $I/I_0$
(mm )												
0	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00	100	2.00
1	75.0	1.875	78.3	1.894	79.8	1.902	80.4	1.905	82.6	1.917	83.3	1.921
2	57.9	1.763	63.0	1.799	65.3	1.815	67.2	1.828	69.8	1.839	71.4	1.854
3	46.6	1.668	51.3	1.710	54.4	1.736	57.8	1.762	60.5	1.782	62.2	1.794
4	38.0	1.580	42.8	1.631	46.2	1.665	50.0	1.699	53.0	1.724	55.0	1.741
6	26.1	1.417	31.7	1.501	34.7	1.540	37.7	1.577	40.9	1.612	43.6	1.639
11	12.4	1.094	16.6	1.220	19.0	1.279	22.0	1.342	25.1	1.399	26.6	1.425
16	6.42	0.807	9.28	0.968	11.1	1.046	14.0	1.145	16.5	1.218	17.6	1.245

standard conditions as the facilities permitted.<sup>23</sup>

Since, as pointed out by Lauritsen,<sup>24</sup> the international definition of the roentgen permits disturbing conditions to enter at these high potentials, our measurements were made according to the revised definition of the roentgen recommended by the Radiological Society of North America Standardization Committee.<sup>25</sup> Here all forms of scattered radiation are eliminated

<sup>23</sup> Only a brief description of these is given here as others will undoubtedly publish a more adequate one.

<sup>24</sup> C. C. Lauritsen, *Am Jour Roentgenol and Rad Ther*, 1933, XXX, 380.

<sup>25</sup> "The roentgen is the quantity of x-radiation which when the secondary electrons are fully utilized and the effects of all scattered radiation avoided, produces in one cubic centimeter of atmospheric air at 0° C and 76 cm mercury pressure, such a degree of conductivity that one E.S.U. of charge is measured under saturation conditions."

as far as possible from the measuring volume of the ionization chamber.

The end of the tube containing the target and its water jacket was surrounded by a lead cap 1 inch thick in which a hole about  $\frac{3}{4}$  inch in diameter was drilled to serve as a window for passing the radiation. The filters were inserted in the beam immediately adjacent to the lead cap, and the limiting diaphragm for the ionization chamber placed 35 cm from these. This diaphragm consisted of a 2.5 cm square hole half way out the radius of a large circular lead disc 2.54 cm thick. Following the technique described by Lauritsen, the beam was cut off, without altering the amount of extraneous radiation entering the ionization chamber, by rotating this lead disc on its geometrical axis. The difference in reading of the ionization chamber magni-



tude with the limiting diaphragm open and closed eliminated the effect of radiation scattered from the room

The ionization chamber was of the parallel aluminum plate type, having a 28

in reasonably close agreement with the sum of potentials measured individually on each of the cascaded units by the manufacturer

The resulting semilogarithmic copper

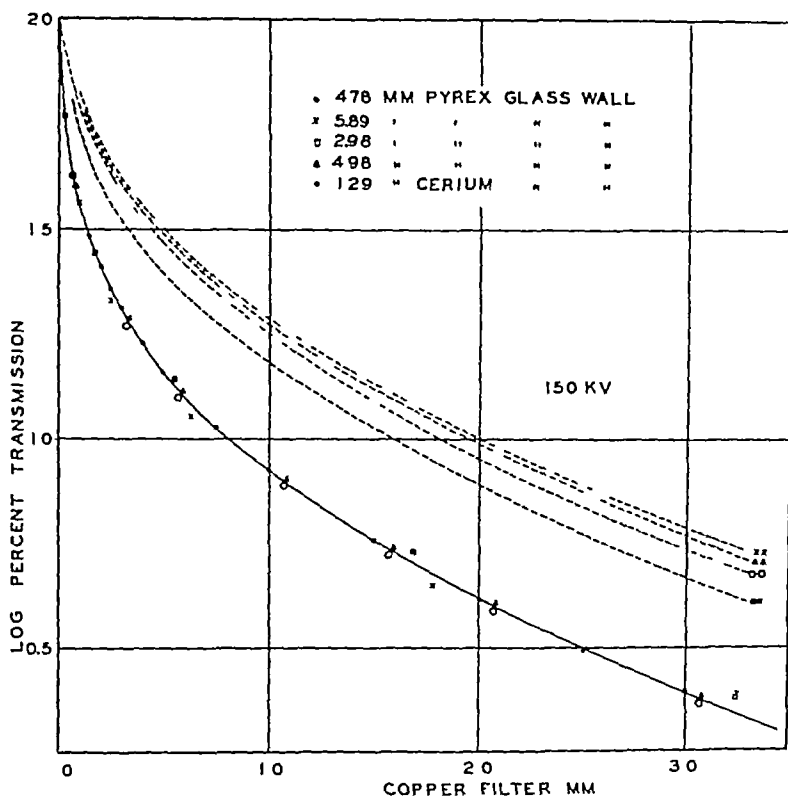


Fig 5 Absorption curves made with several tubes showing the correction for wall effect

cm spacing between the plates. That this separation was probably sufficient, at the voltages used, is concluded from cloud expansion photographs<sup>26</sup> which show that at a considerably higher peak voltage the bulk of the ion tracks are confined within 10 cm of the sides of the beam.

The ionization current was measured by a high sensitivity galvanometer and voltages—corrected to sea level—by the spark gap between 50-cm spheres placed in accordance with 1928 A I E E standards. These potential measurements were

absorption curves, for the indicated excitation potentials and an initial filtration equivalent to about 6 mm of copper, are plotted in Figure 6. Along with these is also plotted the curve for radiation excited by 180 KV (constant) and initially filtered by 48 mm of pyrex glass—equivalent to 0.1 mm of copper, that obtained by Mayneord<sup>27</sup> for 370 KV (constant), but an unstated initial filtration, and, of radiation from a sample of Ra (B + C) after "a heavy" initial filtration (also from Mayneord). The half value

<sup>26</sup> C C Lauritsen. Personal communication

<sup>27</sup> W V Mayneord. Brit. Jour. Radiology, N S, 1933, VI 321

TABLE VI—COPPER AND ALUMINUM EQUIVALENTS OF PYREX GLASS FOR RADIATIONS EXCITED BY VARIOUS CONSTANT POTENTIALS AND FILTERED BY 1.3 MM. OF CERIUM GLASS (COPPER EQUIVALENCE, ABOUT 0.02 MM.)

Thick- ness of pyrex	100 K V				110 K V				120 K V				130 K V		150 K V	
	Log p c trans- mission	Cu thickness	Al thickness	Log p c trans- mission	Cu thickness	Al thickness	Log p c trans- mission	Cu thickness	Log p c trans- mission	Cu thickness	Al thickness	Log p c trans- mission	Log p c trans- mission	Cu thickness	Log p c trans- mission	Cu thickness
0 mm	2 00	0 mm	0 mm	2 00	0 mm	0 mm	2 00	0 mm	2 00	0 mm	0 mm	2 00	2 00	0 mm	2 00	0 mm
2	1 657	02	80	1 667	025	95	1 720	025	1 756	025	1 05	1 766	1 804	023	1 804	024
4	1 477	067	2 10	1 508	064	2 15	1 539	066	1 604	066	2 22	1 604	1 640	065	1 640	070
6	1 354	115	3 52	1 382	117	3 70	1 405	125	1 459	125	3 80	1 459	1 512	126	1 512	124
8	1 265	157	5 00	1 301	167	4 70	1 330	175	1 362	175	5 25	1 362	1 428	180	1 428	180
10	1 176	205	5 95	1 225	22	6 15	1 258	23	1 292	23	6 6	1 292	1 356	237	1 356	245
12	1 079	260	7 25	1 146	28	7 40	1 182	30	1 225	30	7 9	1 225	1 288	30	1 288	32

layer line is also inscribed at  $\log_{10} 50 = 1.70$

Owing to the very different excitation potentials and initial filtrations involved in radiations of Figure 6, as compared with

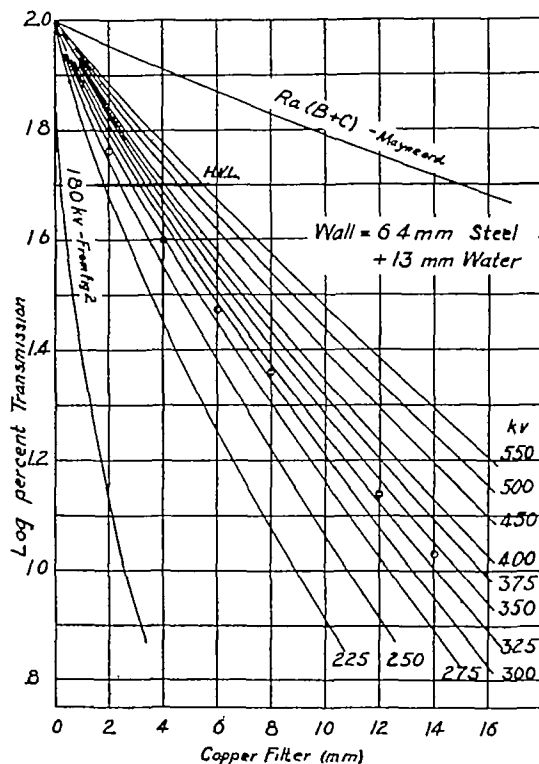


Fig 6 Copper absorption curves above 225 K V, voltages are peak values which are the same as the effective values within the limits of error of measurement

those of Figures 1 and 2, no attempt is made to correlate the absorption curves of Figure 6 with the basic curves of Figure 1

For the 370 K V (constant) curve of Mayneord the initial filtration was confined to the tube wall and hence was of much smaller copper equivalent than that (about 6 mm) in our measurements. In this respect Mayneord's curve agrees with our 375 K V curve at the lower copper filtrations in that his drops the more rapidly as it should, but at the highest filtrations somewhat greater slope of our curve denies the agreement. Since his measurements were made with a thimble chamber of unknown wall effect, it seems rather

TABLE XII —ALUMINUM EQUIVALENTS OF LIME GLASS FOR RADIATIONS EXCITED BY VARIOUS CONSTANT POTENTIALS AND FILTERED BY 0.45 MM OF LIME GLASS

Thickness of lime glass	60 K V		80 K V		100 K V	
	Log p c transmission	Al thickness	Log p c transmission	Al thickness	Log p c transmission	Al thickness
0 mm	2.00	0 mm	2.00	0 mm	2.00	0 mm.
5	1.607	.42	1.690	.47	1.751	.48
1.0	1.516	.84	1.558	.86	1.605	.88
1.5	1.403	1.26	1.461	1.38	1.526	1.33
2.0	1.295	1.72	1.373	1.76	1.459	1.78
2.5	1.185	2.16	1.286	2.23	1.395	2.24
3.0	1.072	2.56	1.190	2.74	1.322	2.77

gratifying that the results are not even more divergent

Inasmuch as our curves of Figure 6 were obtained with nearly constant potential—2 per cent ripple—they may serve as standard for specifying radiation quality within the range of excitation potentials covered and for the initial filtration of about 6 mm of copper. Absorption curves obtained with a greater initial filtration can be correlated with these curves of Figure 6 just as those of Figure 2 with Figure 1, but not so with curves for radiation of lower initial filtration because of the uncertainty with which the magnitudes can

be extrapolated toward the higher transmissions. In other words, although these curves can be of value as standards, they do not have the range of application reserved to basic curves—*i e*, of radiation subjected to zero initial filtration.

We would suggest, therefore, that in specifying the radiation in this high potential range the peak of the excitation voltage be stated when possible along with the equivalent constant voltage until further studies have been made.

Recognition is due to Mr. C. F. Stoneburner of this laboratory for his valuable assistance in obtaining much of the data

# RECENT ADVANCES IN ENCEPHALOGRAPHY<sup>1</sup>

By CORNELIUS G. DYKE, M.D., and LEO M. DAVIDOFF, M.D., *New York City*

ENCEPHALOGRAPHY, in spite of its relatively recent development, is already one of the important diagnostic procedures used in neurologic and neurosurgical clinics. The method has attained this degree of importance even though up to the present time interpretation of the encephalograms has been based only upon the gross abnormalities seen in the ventricles and the subarachnoid space. Reliance upon this method of diagnosis will undoubtedly continue to increase as the finer cerebral structures are recognized and the significance of abnormal variations in them is appreciated.

The increase in the accuracy of encephalographic diagnosis depends upon a thorough acquaintance with the appearance of the normal cerebral structures. It, therefore, seems advisable to describe the various structures which can be outlined when the cerebrospinal fluid spaces are filled with air.

Two phases of encephalography will be presented here: the technic, and the appearance of the normal subarachnoid space and the structures bordering upon or contained within it.

## TECHNIC

The technic of encephalography varies from one clinic to another and each method has its good and its less favorable features. The method employed at the Neurological Institute of New York, the description of which follows, has proved to be simple and safe in over 1,100 cases.

The evening before encephalography is to be performed, the patient is given sodium amytal, grs 3 (0.2 gram), to insure a restful night. The following morning the dose is repeated an hour prior to the

procedure, and about fifteen minutes before the lumbar puncture the patient is given morphine sulphate hypodermically: adult, grs  $\frac{1}{6}$  to  $\frac{1}{4}$  (0.01 to 0.015 gram), children, grs  $\frac{1}{12}$  to  $\frac{1}{8}$  (0.005 to 0.007 gram). Breakfast is withheld. Following this, the patient is sent to the roentgen-ray department where the entire procedure is carried out.

During the withdrawal of fluid and the introduction of air, notes are made of the patient's status, blood pressure, pulse, respiration, or any change in condition such as sweating, pallor, headache, or syncope. To combat these symptoms, aromatic spirits of ammonia and caffeine sodium benzoate have proved sufficient and are always kept at hand.

The patient is seated on a small bench with the forehead resting against an upright Potter-Bucky diaphragm. Lumbar puncture is made with the patient in this position under local anesthesia (procaine). Even when a general anesthesia is used, the same position is employed, this position being maintained throughout the procedure. Only one lumbar puncture is made through the third or fourth lumbar interspace. The pressure of the spinal fluid is recorded and 10 c.c. of cerebrospinal fluid are withdrawn and 5 c.c. of air injected. Atmospheric air for injection is sucked into the syringe through several thicknesses of sterile gauze to avoid possible contamination by air-borne bacteria. It is important to withdraw the fluid and inject the air slowly so that the intracranial pressure changes will not be abrupt. The fluid should be allowed to displace the plunger of the syringe without using suction. In the average case one minute is required for the removal of 5 c.c. of fluid. Five c.c. of air are then injected at a rate of speed equal to that for the withdrawal of the fluid. After the initial 10 c.c. of

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

TABLE XII —ALUMINUM EQUIVALENTS OF LIME GLASS FOR RADIATIONS EXCITED BY VARIOUS CONSTANT POTENTIALS AND FILTERED BY 0.45 MM OF LIME GLASS

Thickness of lime glass	60 K V		80 K V		100 K V	
	Log p c transmission	Al thickness	Log p c transmission	Al thickness	Log p c transmission	Al thickness
0 mm	2.00	0 mm	2.00	0 mm	2.00	0 mm
5	1.607	.42	1.690	.47	1.751	.48
1.0	1.516	.84	1.558	.86	1.605	.88
1.5	1.403	1.26	1.461	1.38	1.526	1.33
2.0	1.295	1.72	1.373	1.76	1.459	1.78
2.5	1.185	2.16	1.286	2.23	1.395	2.24
3.0	1.072	2.56	1.199	2.74	1.322	2.77

gratifying that the results are not even more divergent

Inasmuch as our curves of Figure 6 were obtained with nearly constant potential—2 per cent ripple—they may serve as standard for specifying radiation quality within the range of excitation potentials covered and for the initial filtration of about 6 mm of copper. Absorption curves obtained with a greater initial filtration can be correlated with these curves of Figure 6 just as those of Figure 2 with Figure 1, but not so with curves for radiation of lower initial filtration because of the uncertainty with which the magnitudes can

be extrapolated toward the higher transmissions. In other words, although these curves can be of value as standards, they do not have the range of application reserved to basic curves—*i e*, of radiation subjected to zero initial filtration.

We would suggest, therefore, that in specifying the radiation in this high potential range the peak of the excitation voltage be stated when possible along with the equivalent constant voltage until further studies have been made.

Recognition is due to Mr C F Stoneburner of this laboratory for his valuable assistance in obtaining much of the data

of exposures has often been repeated within a week and no untoward effects have ever been noted

The symptoms encountered during and after the procedure may be headache, nausea, vomiting, cyanosis, pallor, perspiration, chilliness, drowsiness, poor pulse, and a fall of the blood pressure. Headache is the first symptom of which the patient usually complains. Ordinarily, this occurs after the injection of 20 c c of air but it may be complained of before. One or several of the other symptoms then follow rapidly. The great advantage of using the smaller amounts of air is that frequently, before any or many of the symptoms have appeared, the procedure is completed. In other words, it has been found at the Neurological Institute that *the number and severity of the symptoms both during and following encephalography are directly proportional to the quantity of air that has been injected*

#### THE CEREBRAL SUBARACHNOID SPACE THE BASAL CISTERNS

The arachnoid adheres closely to the pia mater everywhere except over parts of the ventral surfaces of the brain and the sulci. In the former region, the leptomeninges are widely separated from each other and form spaces called "the subarachnoid cisterns" (Fig 1). The cisterns communicate freely with one another and with the spinal subarachnoid space. They are usually named according to the cerebral structures which bound them: thus, there is a cisterna magna, pontis, interpeduncularis, chiasmatis, laminae terminalis, corporis callosi, fossae Sylvii, and ambiens. These cisterns have a fairly constant appearance in the roentgenogram and many of them are visualized in a high percentage of cases. For this reason, their absence or distortion in a roentgenogram is often of diagnostic significance.

*Cisterna Magna*—In 1874,<sup>2</sup> this cistern was designated by Key and Retzius as the

"Cisterna Magna Cerebello-Medullaris." According to them, the cistern is directly continuous with the subarachnoid space of the spinal canal. On entering the cranial cavity at the foramen magnum, the subarachnoid space expands greatly in all directions to form the cisterna magna. Dorsally, it extends over the medulla oblongata, the tela choroidea of the fourth ventricle, and the cephalic and ventral portion of the vermis of the cerebellum. It includes, moreover, the larger part of the vallecule and continues laterally over the tonsils and a portion of the ventral and caudal aspects of the cerebellar hemispheres. Cephalically, the cistern is continuous with the cisterna pontis, while dorsally it is continuous with the cisterna ambiens.

The appearance of the cistern in the roentgenogram varies considerably in size and shape. It is best visualized in the lateral stereoscopic views and may be easily identified if one follows the air upward along the dorsal aspect of the spinal cord through the foramen magnum. Usually it appears as a single or double sickle-shaped shadow, the inner margin being concave ventrally, the outer margin paralleling the inner surface of the occipital bone. The cistern extends from the foramen magnum to the grooves for the transverse sinuses, being limited cephalically by the tentorium at a point opposite the internal occipital protuberance (Fig 2). The cerebellar vermis produces the inner concave margin. Here in the mid-line the cistern occupies the vallecule, is deepest, and is the portion most easily seen in lateral encephalograms. The lateral extensions of the cistern are visible only when the films are viewed stereoscopically. The depth of the cistern in the vallecule varies from 5 mm to 2 cm in the encephalogram.

Frequently the air in the cisterna magna extends dorsally and cephalically over the dorsal surface of the cerebellum, to become continuous with the air in the cisterna ambiens. When the air penetrates into the cerebellar sulci, it appears irregularly scalloped as it passes between the indi-

<sup>2</sup>Nord Med Archiv, 1874



Fig 1 Sagittal hemisection of the brain with the pialarachnoid and blood vessels undisturbed (A) anterior cerebral artery, (B) anterior communicating artery, (C) cisterna chiasmatis, (D) optic nerve, (E) optic chiasm, (F) infundibulum, (G) tuber cinereum, (H) oculomotor nerve, (K) corpora mammillaria, (L) posterior cerebral artery, (M) cisterna ambiens (central portion), (N) cisterna interpeduncularis

fluid have been withdrawn and 5 c c of air injected, 5 c c of fluid and 5 c c of air are alternately withdrawn and injected until the desired amount of air has been introduced. It is desirable to end the procedure with 5 c c less air injected than fluid withdrawn, for it is known that 100 c c of air at room temperature (20° C) when raised to body temperature (37.5° C) expands to a volume of approximately 103 cubic centimeters. An 18-gauge spinal puncture needle is used and a short piece of rubber tubing, 4 cm in length, connects the needle and the syringe. This tubing allows considerable manipulation of the syringe without affecting the needle, and may be compressed with the thumb and forefinger instead of using a stop-cock.

There is still considerable debate concerning the optimum amount of fluid to be withdrawn and the quantity of air to be injected. At this clinic, the first film is taken in the postero-anterior position after 25 c c of fluid have been removed and 20 c c of air injected. While this film is being developed the procedure is continued, and by the time 45 c c of fluid have been withdrawn and 40 c c of air injected, the wet "20 c c film" is ready to be viewed by the roentgenologist and the operator. From this film the position, shape, and

size of the lateral and often also of the third ventricles may be determined. Having this information, it is quite easy with a little experience to determine the total amount of air that will be necessary to give a satisfactory encephalogram. The estimation of the amount of air to be injected in any particular patient is based upon the fact that the normal ventricular system has a capacity of from 18 to 20 cubic centimeters. The capacity of the cerebral subarachnoid space has not been determined accurately but it has been found that from 50 to 70 c c of air are sufficient to outline the ventricles and subarachnoid space satisfactorily when the ventricles appear normal in the 20 c c film. Patients with larger ventricles require correspondingly larger amounts of air. However, 140 c c of air have been found sufficient even in cases with marked hydrocephalus. Manipulation of the head during the introduction of the air, in order to obtain satisfactory encephalograms, is not essential.

The position of the patient while the roentgenograms are being made has aroused considerable discussion. Many workers favor the vertical position, and others, equally enthusiastic, prefer the horizontal. At this clinic, anteroposterior, postero-anterior, and right and left lateral stereoscopic films are taken with the patient upright. Immediately following these, a complete stereoscopic set of films from the four sides of the head is made with the patient horizontal. This has proved necessary since certain structures appear more often in the vertical films, whereas other structures are most frequently seen in the films taken with the patient recumbent.

The roentgenologic technic used is as follows: (A) Kilovolts, 75 to 80, (B) milliamperes, 25 to 30, (C) time, 3 to 4 seconds, (D) target-to-film distance, 30 inches, (E) intensifying screens, (F) curved Potter-Bucky diaphragm, (G) cloth binder for immobilization, (H) filter, 1 mm aluminum.

It is perfectly safe to take as many as 17 films, routinely. Indeed, the entire series

except the basilar artery, which may be plainly visible for practically its entire length. The profile shadow of the pons Varoli may be seen between the air in the cisterna pontis ventrally and the fourth ventricle dorsally. It corresponds to the appearance of the pons Varoli in the sagittal hemisection of the brain (Fig 2).

*Cisterna Interpeduncularis* — Just cephalad to the cisterna pontis is the cisterna interpeduncularis. Key and Retzius divide this cistern into a superficial (ventral) and a deep (dorsal) portion. The oculomotor nerves pass through the lateral walls of the superficial portion, and the cephalic limit of the lateral portion of the cistern is arch-shaped for their exit. The deep portion of this cistern spreads out laterally between the crura cerebri as well as cephalically over the optic tracts and chiasm, and includes the intercrural trigone with its various structures, the posterior perforated space, the corpora mammillaria, the tuber cinereum, and the infundibulum. These structures, with the deep layer of the piaarachnoid, form the roof of the cistern. The posterior cerebral arteries, the posterior communicating arteries, and many smaller branches entering the neighboring brain substance, also cross the cistern.

The cisterna interpeduncularis is irregularly rectangular in shape in the lateral encephalogram. Its longer borders are formed cephalically by the tuber cinereum and infundibulum, and caudally by the belly of the pons. The short ventral border is formed by the posterior part of the diaphragma sellæ and dorsum sellæ, while the dorsal border is formed by the cerebral peduncles. Encephalographically, it is impossible to recognize a definite boundary between the superficial and deep portions of the cistern when both are filled with air, but the superficial portion is much more frequently filled with air than the cistern as a whole. This cistern was visualized in 92 per cent of encephalograms (Fig 3).

A number of the structures within or adjoining the cistern may be identified in the



Fig 4 No 20,102 Encephalogram presenting the (A) corpora mammillaria in profile, (B) cisterna ambiens, (C) superior medullary velum

encephalogram. The cerebral peduncles, together with the tegmentum of the brain stem, are often visible and are similar in appearance to that seen in a median hemisection of the brain (Figs 1 and 2). These structures are made visible by the presence of air in the cisterna interpeduncularis ventrally and the caudal portion of the third ventricle and aqueduct of Sylvius, dorsally.

The corpora mammillaria were visible in 28 per cent of this series of encephalograms. These bodies form a rounded projection into the cephalic margin of the cistern, measure about 5 mm in diameter, and are continuous with the cerebral mass dorsally (Fig 4).

The tuber cinereum forms a part of the cephalic boundary of the cistern. It appears as a straight line when seen from the side, and extends from the corpora mammillaria caudally and dorsally to the optic chiasm situated cephalically and ventrally. Whenever the cisterna interpeduncularis is well filled with air, the ventral surface of the tuber cinereum is outlined in the encephalogram (Fig 2). Furthermore, when the inferior portion of the third ventricle is well filled with air the dorsal margin of the tuber cinereum is visible. Finally, in those cases in which both the cisterna inter-



vidual folia of the cerebellum (Fig 3), but when it fails to enter these sulci, the air appears evenly distributed over the surface

and act as supports. The lateral divisions are traversed by numerous nerves. The facial and acoustic nerves, which have a



Fig 2 No 24,681 Encephalogram showing (A) cisterna magna, (B) foramen of Magendie, (C) cisterna pontis, (D) cerebral peduncles, (E) cisterna chiasmatis, (F) diaphragm sellae, (G) lamina terminalis (H) pons Varolii, (I) fourth ventricle



Fig 3 No 24,777 Lateral encephalogram outlining (A) cerebellar folia (B) posterior cerebral artery (C) infundibulum, (D) optic chiasm and nerves, (E) anterior communicating artery (F) pineal body (G) suprapineal recess of the third ventricle (K) colliculi (L) third ventricle

of the cerebellum without any finger-like projections

Not infrequently a column of air is seen in the mid-line joining the caudal end of the cisterna magna and the fourth ventricle. In many instances, even after careful stereoscopic study of the films, no break in this streak of air can be detected and the communication between these two cavities, presumably the foramen of Magendie, is therefore demonstrable (Fig 2)

**Cisterna Pontis**—On the ventral aspect of the pons, the cisterna pontis is located. This cistern has free communication caudally with the cisterna magna and cephalically with the cisterna interpeduncularis. The cisterna pontis is divided into three parts, a medial and two lateral. The former presents a tunnel-like space in which the basilar artery runs along the ventral aspect of the pons in the mid-line. The artery floats freely in this space except for a few trabeculae which are attached to it

rather wide arachnoidal sheath, are situated close to the caudal border of the pons. Medially, the cistern is crossed by the abducens nerves, which in their course cephalically and laterally float freely within the cistern for a considerable distance. In the lateral portion of the cistern lie the trigeminal nerves which are surrounded at their exit by a roomy arachnoidal sheath. The depth of the cisterna pontis medially varies from 4 to 6 millimeters.

This cistern is visible in the encephalogram in about 65 per cent of all cases (Fig 2), and is best seen in the lateral encephalograms. Its ventral border is delimited by the dorsum sellae and forms a straight line when seen from the side, while the dorsal boundary is formed by the belly of the pons and is concave ventrally. This cistern measures from 5 to 9 mm in its anteroposterior diameter. While numerous structures cross the cistern, it has never been possible to identify any of them

lateral enlargements of the subarachnoid space which communicate freely with the midline cisternæ. Laterally, they are continuous with the subarachnoid space within the Sylvian fissures and are designated as

spheres and the cerebellum, while its medial walls are limited by the brain stem and the lateral pontine cistern. The cisterna ambiens extends along the floor of the cerebro-cerebellar fissure and passes caudally and

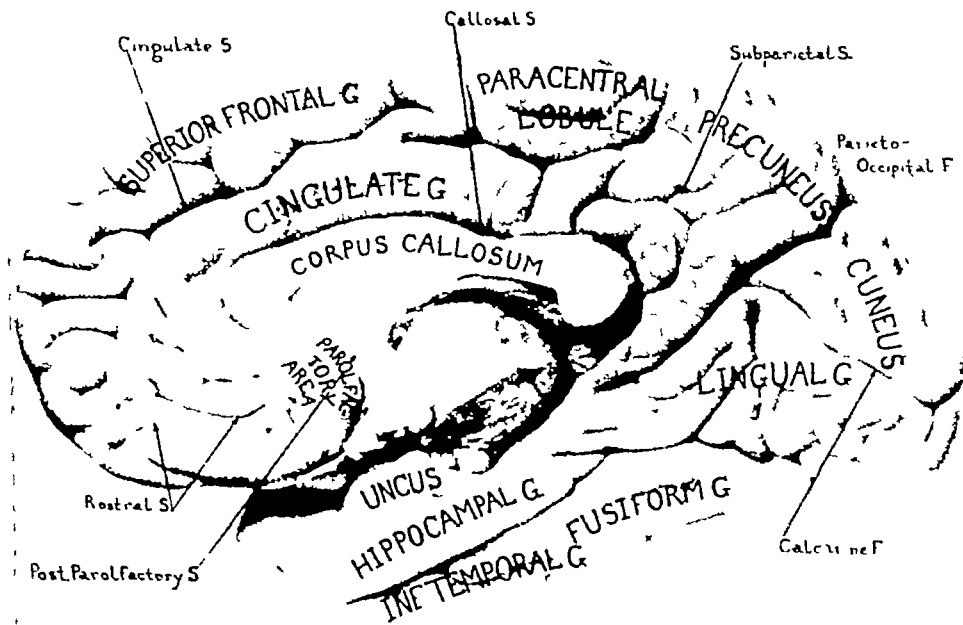


Fig 5 Mesial aspect of brain reproduced from Retzius' "Das Menschenhirn" Vol II, Plate LXI (Labelled by authors)

the cisternæ fossæ Sylvii. Within them are suspended the middle cerebral arteries and their primary branches. The arachnoid stretches across the mouth of the fissure, and the depth of the cistern in its widest portion is from 15 to 17 mm, measuring from the stretched arachnoid to the floor.

In the anteroposterior encephalogram, this cistern is seen slightly caudal to the wings of the sphenoid bone. It may also be seen in the lateral encephalogram.

**Cisterna Ambiens**—On each side of the cisterna interpeduncularis, and caudal to the medial portion of the cisternæ fossæ Sylvii, is the wide cisterna ambiens which passes caudad in close relationship to the crura cerebri to encircle the mid-brain. Its lateral limits are formed by the hemi-

dorsally on both sides to join its fellow of the opposite side dorsal to the colliculi. Dorsally, it is limited by an arachnoid membrane which stretches between the cerebrum and cerebellum, thus surrounding the mid-brain and, with the ventral cisterns, making a complete cisternal investment about the brain stem.

According to Key and Retzius, the subarachnoid space between the corpora quadrigemina, the cephalic aspect of the cerebellum, and the splenium of the corpus callosum is also a part of the cisterna ambiens (Fig 1). The vena magna Galeni leave the brain in this region. More recent authors have named this space the "cisterna venæ magnæ cerebri."

In the lateral encephalogram the cistern consists of two parts, a dorsal one (Fig 4)

peduncularis and third ventricle are filled with air, the profile of the tuber cinereum is visible between the two air-filled spaces.

Frequently two shadows of increased density are seen within the cisterna interpeduncularis. One of these, about 2 mm in width and 1 cm in length, is linear in shape and runs obliquely across the cistern in a dorso-ventral direction parallel to the tuber cinereum. This shadow corresponds in size, shape, and position to the oculomotor nerves. The other shadow usually appears circular in outline and is about 3 mm in diameter, occasionally is rod-shaped, and is seen to cross the shadow representing the oculomotor nerves obliquely. It corresponds to the only other structures of demonstrable size within the interpeduncular space, namely, the posterior cerebral arteries (Fig 3).

*Cisterna Chiasmatis*—Extending cephalically from the cisterna interpeduncularis, ventral to the chiasm, and rostrally between the mesial aspects of the diverging optic nerves, there is a superficial shallow cistern, namely, the cisterna chiasmatis.

The cisterna chiasmatis was visible in 78 per cent of the encephalograms made at this clinic (Fig 3). It is extremely irregular in outline and is usually filled unevenly with air, so that no measurements of it can be made. The cephalic part is shaped somewhat like an inverted comma. The lateral portions of the cistern are visible only occasionally as small irregular globules of air.

The caudal extension of the cistern borders the anterior portion of the diaphragma sellae. The subarachnoid space on the hypophyseal or ventral surface of the sellar diaphragm is seldom seen, so that the diaphragm is usually outlined by air only on its dorsal surface (Fig 4).

The infundibulum of the hypophysis is surrounded by the air in the cisterna chiasmatis and forms a short rod-shaped shadow of greater density, running obliquely in a dorso-ventral direction (Fig 3).

The optic chiasm and nerves are frequently demonstrable in the encephalogram. The chiasm is seen in cross-

section as a small ovoid shadow  $2 \times 3$  mm in size. The optic nerves produce a shadow which is continuous with that of the chiasm—rod-shaped and running obliquely in a dorso-ventral direction, parallel to the shadow representing the oculomotor nerves (Fig 3).

*Cisterna Laminae Cinereae Terminalis*—The cisterna laminae cinereae terminalis is a median cistern situated dorsal to the cisterna chiasmatis. It spreads out in front of the chiasm upon the free cephalic surfaces of the optic nerves in front of the lamina terminalis, and extends upward along the rostrum of the corpus callosum, filling the spaces between these parts and the ventral surface of the frontal lobes.

In the encephalogram, this cistern when filled with air appears as a narrow streak of decreased density (Fig 2). It runs in almost a vertical direction and, not infrequently one sees within it a circular shadow of increased density about 5 mm dorsal and slightly cephalad to the optic chiasm. This shadow is produced by the anterior communicating artery (Fig 3).

The lamina terminalis forms the caudal boundary of this subarachnoid space and its cephalic surface is outlined in the encephalogram whenever the cistern is filled with air. Moreover, when the ventral and cephalic portions of the third ventricle are also filled with air, the lamina terminalis may be seen in profile as a band-like shadow of increased density (Fig 2).

Other subarachnoid spaces exist in continuation with the cistern of the lamina terminalis. These accompany the anterior cerebral arteries as they curve around the corpus callosum and are enclosed by the arachnoidal membranes which extend from the ventral margin of the falx to the corpus callosum. Within this membrane is another cistern, the cisterna corporis callosi. In the anteroposterior encephalogram, the air in this cistern is seen to be continuous with that in the callosal sulci laterally.

*Cisternae Fossae Sylvii*—Between the ventral surface of the frontal lobes and the tips of the temporal lobes there are two

cumstances accurate identification is more difficult. All of the major and most of the secondary convolutions and sulci have been at times seen and recognized in this series of encephalograms.

#### MEDIAL ASPECT OF THE BRAIN

*The Longitudinal Cerebral Fissure*—The great cleft between the hemispheres into which the falx projects is often outlined by air. This appears as a heavy streak bisecting the cerebral contents as seen in the anteroposterior or postero-anterior views. Occasionally this fissure is shifted from its median position, as, for example, by a tumor. In encephalograms in which the ventricles do not contain air this displacement may be of great diagnostic significance.

There are four sulci on the medial surface of the brain which are frequently visible in the encephalogram, the callosal, cingulate, parieto-occipital, and calcarine sulci (Figs 5 and 6). The rostral, parolfactory, and subparietal sulci are less frequently seen. Secondary sulci are often noted but they are quite variable, and anatomists have apparently left them unnamed.

*Corpus Callosum and Callosal Sulci*—The corpus callosum forms the roof of the lateral ventricles, and is separated dorsally from the rest of the brain by the callosal sulci. In the encephalogram, in the anteroposterior view, the callosal sulci are often recognizable as two small narrow horizontal streaks extending laterally from the mid-line for about 5 millimeters. Medially, the air in the two sulci coalesces with the air in the longitudinal fissure along the inferior margin of the falx cerebri and the air in the cisterna corporis callosi. The combined shadow is somewhat triangular in shape, and is separated from the shadows of the lateral ventricles by an area of greater density forming a white band on the film. The latter represents the corpus callosum which may vary in thickness at the mid-line from 0.3 to 1.2 centimeters. In the encephalogram with

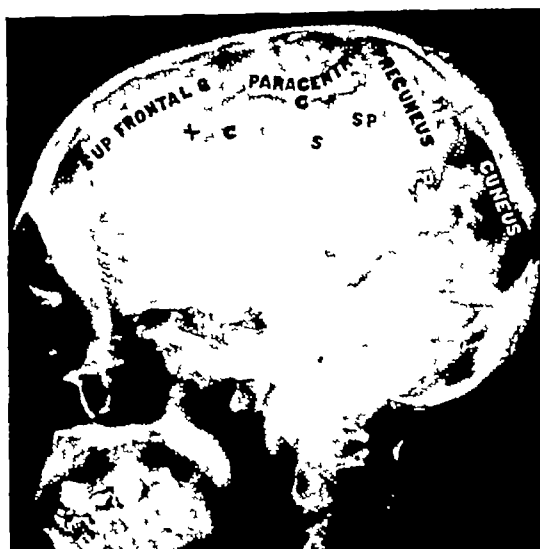


Fig 6 No 23,096 Demonstrating many of the sulci and convolutions of the medial aspect of the brain (CS) callosal sulcus, (C) cingulate sulcus, (SP) subparietal sulcus, (PO) parieto occipital sulcus, (X) cingulate gyrus

normal-sized ventricles the corpus callosum can be seen as it dips downward in the mid-line between the wings of the "butterfly" pattern formed by the lateral ventricles. The internal angle of this dip often becomes progressively greater as the size of the lateral ventricles increases.

Having located the position of the corpus callosum and the callosal sulci in relation to the lateral ventricles as seen in the anteroposterior view, one may now examine the lateral views for the position of these structures. The landmarks for the corpus callosum are formed by the air contained in the ventricles below, and in the unbranched callosal sulci above. Depending upon the amount of air in the callosal sulci, the entire callosum may be outlined (Fig 6) or only the mid-portion (which is the usual condition), or the posterior portion alone, including the splenium, or the anterior portion alone, including the genu.

*Cingulate Gyrus and Sulcus*—Directly dorsal to the corpus callosum on either side of the mid-line are the cingulate gyri (Fig 6). In the lateral encephalogram, the gyrus is made visible by the air in the callosal fissure below it and in the cingulate

which is single and situated above the colliculi, and a ventral portion (Fig 4) which is paired and situated between the lateral aspects of the cerebral peduncles and the mesial aspects of the hippocampal gyri. The former is bounded by the splenium of the corpus callosum, suprapineal recess, pineal gland, and the straight sinus in the tentorium cephalically and dorsally, the colliculi and superior medullary velum ventrally, and the vermis of the cerebellum caudally. This portion of the cistern is somewhat rectangular in shape when seen from the side (Fig 4).

The paired ventral portion of the cistern consists of two slit-like shadows, the superior margin of which is slightly concave upward. This represents that portion of the cistern between the crura cerebri and the hippocampal gyri. The air in this portion of the cistern is directly continuous with that in the hippocampal fissures (Fig 4).

The pineal gland is frequently outlined in the encephalogram by air in the cisterna ambiens caudally and ventrally, and above by the air in the suprapineal recess (Fig 3). The corpora quadrigemina are often visible due to the presence of air in the cisterna ambiens above and by air in the aqueduct of Sylvius below (Fig 3). The superior medullary velum can be seen where it joins the roof of the mid-brain when it is outlined by air in the cistern dorsally and in the fourth ventricle ventrally (Fig 4).

The other structures suspended within this cistern, such as the great vein of Galen, the posterior cerebral arteries, the superior cerebellar arteries, and the trochlear nerves, have not been individually identified in this location.

#### THE CEREBRAL CONVOLUTIONS AND SULCI

Up to the present time, with very few exceptions, the cerebral sulci as seen in the encephalogram have been considered collectively, and only insofar as they have shown evidence of widening (cerebral atrophy) or obliteration (adhesive arach-

noiditis). However, information of much value may be obtained by careful study of the individual sulci, and the gyri outlined by them, *e g* (a) closer acquaintance with the appearance of the cerebrum in the living, presumably normal, individual may be gained, (b) anomalies may be more readily recognized, (c) cerebral lesions may be more definitely localized. Not infrequently, after the introduction by the lumbar route, air fails to enter the ventricles while the sulci are well outlined. It is, therefore, just as important to be able to draw conclusions from the appearance of the sulci when the ventricles are not visible, as it is to make a diagnosis from the appearance of the ventricles.

In order to demonstrate the individual sulci and to avoid confusion, films have been selected for illustration in which a few sulci alone are well shown. In encephalograms in which all the sulci are filled with air, the identification of individual ones is difficult until considerable familiarity with their usual appearance has been acquired.

We have included in our material the encephalograms of a number of patients with cerebral atrophy. The enlargement of the sulci in these cases permits a greater quantity of air to enter these spaces, thereby demarcating the convolutions and fissures more distinctly than in the normal brain. In this manner the individual sulci may be more readily identified and more satisfactorily reproduced.

Certain sulci are regularly visible in the encephalogram, others can be recognized only occasionally, and still others only rarely. The sulci on the medial aspect of the hemisphere are much more consistently and more satisfactorily shown than those on the convexity of the brain. The sulci that are most often seen and most easily recognized, in the order of the frequency with which they appear, are the cingulate, parieto-occipital, calcarine, callosal, Sylvian, superior temporal, central and lateral occipital. The remaining sulci are less frequently visible except when air fills most of the other sulci, under which cir-

is possible to recognize the important divisions of the brain demarcated by these sulci as seen in lateral roentgenograms (Fig 6) Between the parieto-occipital fissure caudally and the dorsal sweep of the marginal limb of the cingulate sulcus cephalically is located the precuneus, or the quadrate lobule Ventrally this subdivision of the mesial surface is demarcated by the subparietal sulcus and dorsally by the dorsal margin of the brain Through the center of this lobule runs another small fissure which is sometimes filled with air, the superior parietal sulcus

The part of the brain between the marginal limb and the strongly developed dorsal branch of the cingulate sulcus is the paracentral lobule, limited above by the dorsal margin of the brain, and ventrally by the cingulate sulcus Cephalad to this lobule may be seen the outline of the mesial portion of the superior frontal gyrus, also called the "marginal gyrus"

*Parolfactory Area and Sulci*—The parolfactory area on the mesial surface of the hemisphere is bounded cephalically by a small, inconstant, anterior, parolfactory sulcus and caudally by the posterior parolfactory fissure The latter is the ventral extension of the cephalic portion of the callosal sulcus and separates the parolfactory area from the subcallosal gyrus It is not infrequently demonstrable in lateral encephalograms

*Rostral, Orbital, and Olfactory Sulci*—The ventral portion of the mesial frontal (marginal) cortex is indented by two or three sulci which are arranged concentrically with the ventral and cephalic portions of the cingulate sulcus These are the rostral sulci which divide the ventro-mesial area of the frontal cortex into a number of small gyri In the encephalogram the rostral sulci are occasionally quite evident and can be seen readily when they become enlarged as a result of cerebral atrophy

A number of smaller sulci on the orbital surface of the frontal lobe, such as the complex orbital sulci and the olfactory sulcus, are occasionally visible in the encephalogram

#### LATERAL ASPECT OF THE BRAIN

The lateral aspect of the cerebral hemisphere presents a much more complex convolutional pattern than that seen on the medial surface (Fig 7) This is further complicated by the convexity of the lateral surface of the brain Because of these complicating features, some method for orientation is essential, and the various systems of craniocerebral topography have been investigated with this in mind The method developed by Taylor and Haughton which utilizes roentgenography, seems to be best suited to the needs of this study These authors, after formalin fixation of the brain *in situ* for three weeks, made a median sagittal section of the head The falx cerebri was taken out and the hemisphere removed Malleable tin wire was then placed in the major sulci and the chief bony landmarks were also marked with similar material The hemisphere with the wire in the sulci was then replaced in the skull and lateral roentgenograms were taken These plates showed the relationship between certain fixed points on the exterior of the skull and the sulci as visualized by the wire In this way they were able to establish lines on any head which correspond quite accurately to the location of the major sulci on the convexity of the brain

*Lateral Cerebral Fissure (Fissure of Sylvius)*—In the lateral encephalogram the Sylvian "point" from which the three branches of the Sylvian fissure arise, can be seen about 1 to 2 cm above the tuberculum sellæ From this point the three branches extend cephalically, dorsally, and caudo-dorsally The caudal branch has a characteristic termination, which is usually seen in the encephalogram in cases in which the Sylvian fissure is demonstrable (Fig 8) For more exact identification of the fissure the lines established by Taylor and Haughton may be drawn on the lateral view The wavy shadow representing the air in the fissure will be found to follow the diagrammatic line representing the same structure In order to procure the closest

sulcus above it. The cingulate sulcus is readily recognized in the lateral and anteroposterior encephalographic views, appearing in the lateral encephalogram as a broad dark shadow (Fig 6). The cephalic end of

callosal sulcus, is usually independent and is called the "subparietal sulcus".

In the anteroposterior view, the cingulate sulci appear as narrow horizontal shadows parallel to and about 1 cm dorsal

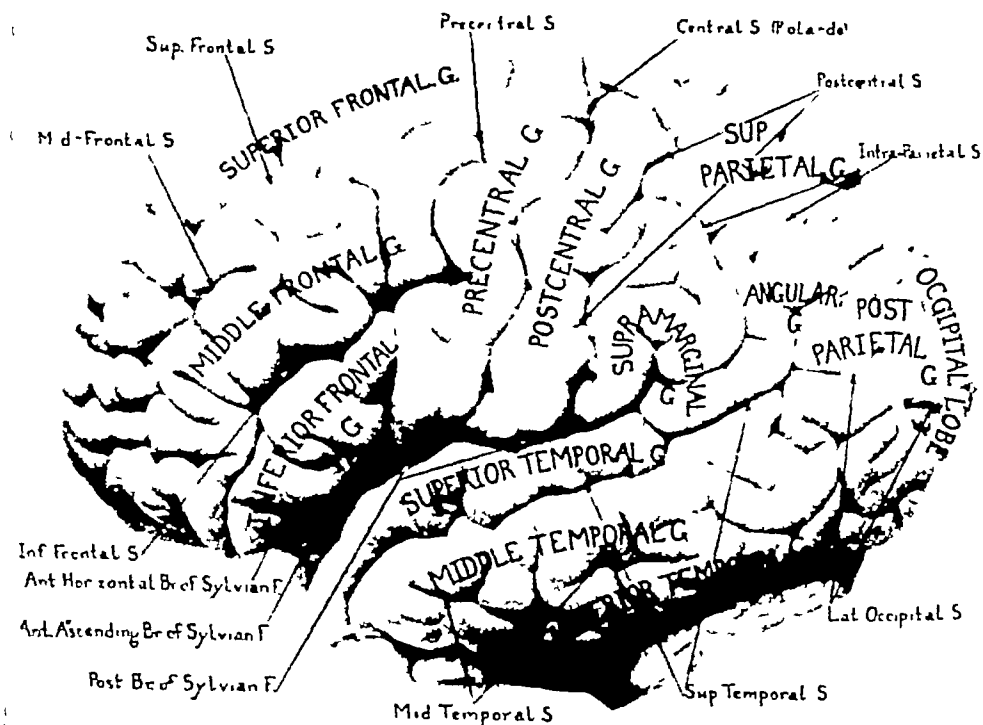


Fig 7 Lateral aspect of brain reproduced from Retzius' *Das Menschenhirn* Vol II Plate LXXII (Labeled by authors)

the sulcus begins about 1 cm anterior to the genu of the corpus callosum and somewhat ventral to it. The sulcus passes upward and forward in front of the curve of the genu of the corpus callosum, at which point it begins to curve backward and upward. In its mid-portion, it is quite smooth for a distance of about 4 cm, where there are, as a rule, two waves or undulations. At the caudal end of the second undulation, the sulcus curves dorsally at a sharp angulation and disappears over the dorsal margin of the hemisphere about 1 cm caudal to the upper end of the fissure of Rolando (Fig 6). The short caudal continuation of the cingulate sulcus, parallel to the splenial portion of the

to the callosal sulci. The shadows of greater density between the air in the callosal and cingulate sulci represent the cingulate gyri.

All of these structures are so characteristic in shape and position that they are easily demonstrable in the lateral encephalograms. The only other sulci which may cause confusion are located on the lateral surface of the brain, and the position of the sulci on the convexity can be easily distinguished from those on the mesial surface by examination of the films in the stereoscope.

*The Precuneus, Paracentral Lobule, and Superior Frontal Gyrus*—With the major sulci identified in the encephalogram, it

*The Central Convolutions and Sulci* — The pattern of the central sulcus is quite constant (Fig 9) In its upper half there is a curve with its concavity cephalically, and in the lower half the direction of this curve is reversed In the encephalogram, the recognition of the fissure is facilitated by (a) its location in the middle of the hemisphere, (b) its relation to the Sylvian fissure, and (c) its characteristic course Further confirmation may be obtained by the use of the Taylor and Haughton lines

In front of the fissure of Rolando is the precentral or motor convolution (Fig 9) This gyrus is about 1 cm in width and is separated from the frontal convolutions proper by the superior and inferior precentral sulci or a combined precentral sulcus (Fig 9) The latter equals in extent the Rolandic fissure itself and runs parallel to it If seen alone in the encephalogram it can be distinguished from the central sulcus by its more cephalic position and its proximity to the anterior ascending ramus of the Sylvian fissure which is less than 1 cm in front of it

Caudal to the central fissure lies the postcentral gyrus (Fig 9), which closely resembles the precentral convolution in size, shape, and direction It is about 1 cm in width and terminates ventrally near the junction of the middle and caudal thirds of the Sylvian fissure This gyrus is often interrupted in its mid-portion by a cephalic extension of the intraparietal sulcus The cephalic boundary of the postcentral convolution is the central fissure The caudal border of the convolution is less frequently seen inasmuch as the superior and inferior postcentral sulci which delineate it are less often outlined with air (Fig 9)

*The Frontal Convolutions and Sulci* — The convexity of the frontal lobe is divided into three major parallel convolutions, the superior, middle, and inferior, running in the horizontal plane roughly at right-angles to the precentral gyrus

In the encephalogram, one or several of the frontal sulci are occasionally seen, to be identified in the anteroposterior, pos-

tero-anterior, or lateral views For some unexplained reason the superior frontal sulcus is rarely visible although its depth, uniform position, and direction should facilitate its recognition The identification of the middle frontal sulcus, although somewhat difficult because its pattern varies considerably, is frequently possible The anterior horizontal and anterior ascending branches of the Sylvian fissure have a rather constant relationship to the inferior frontal sulcus which makes the latter readily recognizable in the encephalogram

*Posterior Pole of the Cerebral Hemisphere* — The convolutional pattern of this portion of the brain is extremely variable, practically no two specimens being even grossly similar This makes the identification of structures in this region difficult in the encephalogram, and only two of the sulci, the intraparietal and the lateral occipital, have been observed with reasonable certainty The former pursues a parasagittal course about 2 cm lateral to the mid-line It begins caudally about 3 cm from the ventral margin of the brain and extends cephalically for about 4 cm although, because of the convexity of the brain, it is foreshortened in the anteroposterior encephalogram The lateral occipital sulcus is infrequently seen when it is visible in the encephalogram, it appears ventral and lateral to the intraparietal sulcus

#### SUMMARY

A technic for encephalography which has been found satisfactory in 1,100 cases is described Emphasis is placed upon the value of taking a trial film after the injection of 20 c c of air, and the possibility of obtaining good encephalograms with much less air (50 to 70 c c) than has usually been introduced heretofore In this way, the symptoms of the patients both during and after the procedure are distinctly lessened The roentgenologic technic is described and the need for stereoscopic films with the patient in the vertical and horizontal positions is shown





Fig 8 No 22,788 This shows especially well the horizontal division of the Sylvian fissure (*PS*). The superior temporal (*ST*) sulcus is seen to parallel the posterior Sylvian branch and the superior temporal convolution lies between them. From these two sulci the location of the supramarginal (*S*) and angular (*A*) gyri is defined.



Fig 9 No 21,296 This is a striking view of the fissure of Rolando (*FR*) and the precentral (*PS*) sulcus locating the central convolution, motor area (*M*) and sensory area (*S*). The view is somewhat distorted due to rotation of the head.

approximation between a particular line in the diagram and the air in the corresponding fissure in the encephalogram, it is essential that the view be a direct lateral one with the two external auditory meatuses practically superimposed.

In the depths of the lateral fissure is located the Island of Reil, a submerged cortical area not visible on the lateral view of the brain unless the overhanging operculum of the frontal and temporal lobes is displaced. The insula is made up of a number of gyri which have a fan-shaped arrangement—the long and short gyri—separated from each other by a series of corresponding sulci. In the anteroposterior encephalogram the surface of the Island of Reil is frequently outlined by a V-shaped collection of air displacing the fluid in the depths of the Sylvian fissure and in the sulci of the insula. The latter may be individually recognized in the lateral encephalogram.

*Temporal Lobe and Sulci*—Using the Sylvian fissure as a landmark, it is possible

to identify the shadows of the other sulci and convolutions in its vicinity. Parallel to the Sylvian fissure and about 1 cm ventral to it is the superior temporal sulcus (Fig 8). This terminates caudally in an upward sweep which is surrounded by the angular gyrus. Between the Sylvian fissure dorsally and the superior temporal sulcus ventrally is situated the superior temporal convolution. About 2 cm ventral to the superior temporal sulcus is the middle temporal sulcus which roughly parallels the former. Between these two sulci the middle temporal convolution is situated. Both the superior and middle temporal sulci, as well as gyri, are at times demonstrable in the encephalogram. The inferior temporal and collateral sulci, located on the ventral aspect of the temporal lobe, have not as yet been identified encephalographically by the authors. This is probably explained by the inability to obtain encephalographic views with the base of the brain in a favorable position for the visualization of air in these sulci.

# ENLARGEMENT OF THE ATELECTATIC LUNG, A ROENTGENOGRAPHIC SIGN OF INFLAMMATION

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WHEN massive atelectasis<sup>1</sup> has formed in an inflamed part of the lungs or when inflammation has developed in a massively atelectatic part, the inflammatory lesion is wholly or mostly invisible roentgenographically. All shadows of the inflammatory lesion cast by x-ray, except those of any large calcific deposits or air-containing cavities present, blend indistinguishably with the homogeneous shadow of the surrounding airless lung. The lung-field is painted out, so to speak, making calcific bodies and cavities visible, since they are distinctly different in radiolucency from atelectatic tissue. Practical disadvantages arise from this, especially in chronic pulmonary infections wherein the clinical signs of the inflammatory lesion are also masked by

the atelectasis. Only the symptoms remain to indicate the nature and extent of the infection, and they are often very inadequate. The disease most prominent in this connection is tuberculosis, with its high incidence and long persistence of both the obstructive and the compressive forms of atelectasis. Bronchiectasis and chronic lung abscess come next in order. The disadvantages are least in acute pulmonary infections in which the symptoms reflect the disease much better and a detailed delineation of the lesion is not so necessary.

The purpose of this paper is to describe a roentgenographic sign indicating the presence and extent of active inflammation in a massively atelectatic part of the lungs, and to present sufficient experimental and clinical evidence to support its validity. The sign rests upon a simple hypothesis concerning pulmonary size, and it requires certain conditions.

*Hypothesis*—A massively atelectatic part of the lungs, like any other solid mass of soft tissue, should swell when inflamed and return to its normal size when free again from inflammation, the amount of swelling being roughly proportional to the activity and extent of the inflammation.<sup>2</sup> Therefore, enlargement of a massively atelectatic part should be a sign of inflammation. If the roentgenologist appreciates the size of the x-ray shadow cast by massively atelectatic uninflamed parts of the lungs in general, he should be able to judge in a given case, by the size of an atelectatic part, whether or not inflammation is present and the approximate degree

<sup>1</sup> Basic differences of usage exist as to the meaning of the term "atelectasis" and as to the criteria of the roentgen diagnosis. The authors' usage (1) is, briefly, as follows. Atelectasis is a state of the lungs in which there is complete airlessness and alveolar collapse in all or in any part, however minute. The lesion is *focal* when it occurs in small scattered areas, giving to the lung a mottled appearance at x-ray examination, and *massive* when it occurs in one or more areas, each being large enough to form the homogeneous "ground-glass" roentgenographic shadow which characterizes any gross, completely airless mass of soft tissue of uniform composition. The "ground glass" shadow is easily recognized, and is the only constant roentgen sign of massive atelectasis. It is usually outlined clearly, so that its shape and distribution permit the lesions of lobar distribution to be distinguished readily from those of sub-lobar or lobular extent. Massive obstructive atelectasis is accompanied characteristically by great displacement of the mediastinum and the *ipso* lateral half of the diaphragm toward the lesion, the displacement being so extensive that it appears at maximum expiration as well as at inspiration. However, when the atelectasis is due to, or at least is associated with, pulmonary relaxation or compression, either or both of these environmental structures is or is not displaced. Any displacement that occurs is irregular in extent and direction.

Both the obstructive and the compressive types of massive atelectasis and only the total uni- or multi-lobar forms are referred to in this article. Focal atelectasis is not considered.

<sup>2</sup> This is contrary to the behavior of the air-containing lung, for as the products of inflammation collect in the latter they are accommodated by a loss of air, and enlargement is prevented. Indeed as measured with the lungs at expiration the pneumonic lung is about normal in size, and at full inspiration, it is much smaller than normal (2 and 3).

The appearance of the subarachnoid cisterns as seen in the encephalograms is discussed. By an examination of the films in the stereoscope it is possible not only to ascertain the size, shape, and position of all the cisterns, but also their relation to the neighboring cerebral structures. In many instances it has been possible to identify the nerves, blood vessels, and portions of the brain which project into or bound the cisterns.

Furthermore, attention has been directed to the identification of the various cerebral convolutions and sulci on the medial and lateral aspects of the cerebral hemispheres.

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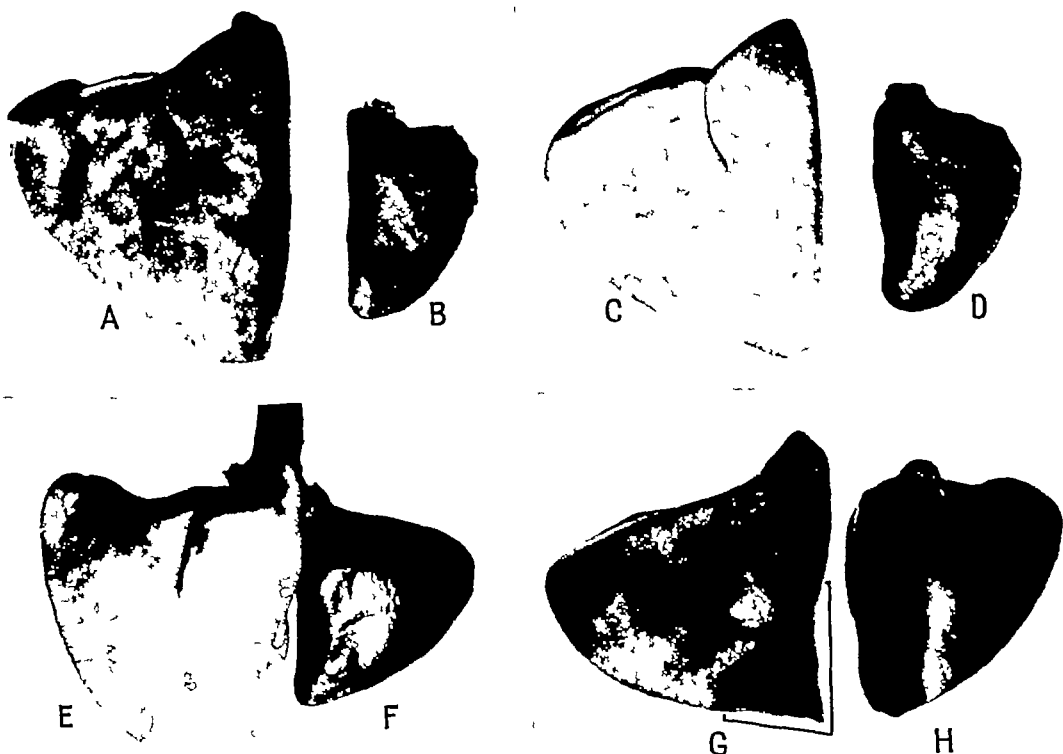


Fig 1 Four pairs of dogs' lower pulmonary lobes, giving the size relationships A, C, E, and G, normal, fully inflated left lower lobes (Bracket shows the only inflamed part) B, atelectatic non-inflamed right lower lobe D, F, and H, atelectatic inflamed right lower lobes, arranged in order of increasing degrees of the inflammation

was sutured Two hours later, the dog was killed by exsanguination, the chest was opened, the lungs were allowed to collapse, and the right and left lower lobes were removed and measured, one at a time, in a volumetric chamber (2) The left lower lobe was then inflated with air to the approximate size which it had *in vivo* at full inspiration and was maintained so while its volume was measured again The lobes were then cut and examined grossly and microscopically

At autopsy, the right lower lobe of both dogs was found to be liver-color, much shrunken, wrinkled, flabby, and entirely airless (Fig 1-B) The cut surface was the same color, dry, and concave At microscopic examination, the alveoli were found to be completely collapsed, the capillaries dilated somewhat, and the

tissues as a whole free from inflammatory exudate The left lower lobes presented nothing abnormal (Fig 1-A) The volumes of the right lower lobes were 50 and 61 per cent of those of the corresponding left lower lobes when the latter were collapsed, and 85 and 59 per cent, respectively, when the left lower lobes were expanded (Table I)

In brief, the result was that the right lower lung lobes were massively atelectatic, free from inflammation, and very small as compared to the corresponding normal left lower lobes, whether the latter were inflated or deflated

*Group 2 Atelectasis with Inflammation of Various Grades*—Each of the three dogs of this group was prepared for thoracotomy as described above, but the operation itself was changed in that the cannula

of the inflammation. Also, he should be able to determine in a series of observations, by any alteration in the size of an atelectatic part, the occurrence of significant changes in the degree of an infectious process.

*Conditions*—(1) The roentgenographic technic should be constant.<sup>3</sup>

(2) In some cases, allowance should be made for shrinkage of the atelectatic part from the contraction of scar tissue. (Although the presence of pulmonary cirrhosis and the amount of shrinkage therefrom in the airless lung cannot always be known, this condition should restrict the value of the sign only to the extent that positive readings—presence of enlargement—would be quantitatively rather than qualitatively inexact, and that negative readings—lack of enlargement—would be inconclusive in completely excluding inflammation.)

(3) The sign should be reliable, only if the possibility of the existence of a neoplasm in the atelectatic part, adding appreciably to the size, is ruled out.

(4) The sign should be regularly usable when the atelectasis involves one entire lobe or group of lobes, since the size and shape of those units are readily carried in mind, but not so, in many cases, when the atelectasis involves only one lobule or a sub-lobar group of lobules, since the proportions of lobules cannot often be remembered.

#### EXPERIMENTAL SUPPORT

Two groups of dogs were used to demonstrate the relationship, by volume, that exists between the massively atelectatic non-inflamed lung lobe, the massively

atelectatic lobe with inflammation of various extents, and the air-containing non-inflamed lobe with various degrees of inflation. In Group 1, two dogs, the right lower lobe was rendered completely atelectatic, and in Group 2, three dogs, the same lobe was first infected and then made atelectatic. The animals were killed, the lungs removed, and the volumes of the right and left lower lobes determined, the left lower lobe being measured both at full inflation and at full collapse. The measurements for the left lower lobe were used to represent the normal size of the right lower lobe.<sup>4</sup>

*Group 1 Atelectasis without Inflammation*—Each of the two dogs of this group was given morphine, anesthetized with ether, tracheotomized, and prepared for positive-pressure breathing. The right pleural cavity was opened with an intercostal incision and, as long as the cavity remained open, the breathing was aided with the respirator. The bronchus supplying the right lower and accessory lobes<sup>5</sup> was encircled loosely with a ligature. A long and very slender rubber tube, which was tipped with a short glass cannula, was passed, by way of the tracheotomy opening, into the bronchus. The ligature was then drawn tightly, without knotting, to secure the cannula temporarily. Through the tube, the two lobes thus cannulated were repeatedly ventilated with pure oxygen,<sup>6</sup> and then were inflated completely with the same gas. Immediately after that, the cannula and rubber tube were withdrawn while the ligature was tied permanently onto the bronchus, to retain the gas and obstruct the lobes. Pneumothorax was excluded by expanding the other lobes with air from the respirator, and the lobes were kept expanded while the incision in the chest wall

<sup>3</sup> Our routine thoracic roentgenograms were made with uniform technic. The patient stands upright, hands on hips, shoulders forward and breast against the cassette changer. Experience shows that small variations in the position of the tube (which is situated centrally, 60 in. from the film) up or down, produce no important changes in the size of the lung fields at that distance. For example, the two films of a stereoscopic pair commonly present little or no difference in pulmonary size, although taken with a vertical tube shift of 5.5 inches.

<sup>4</sup> The two lower lobes of the dog's lungs are exactly or very nearly the same volume (2).

<sup>5</sup> The accessory (subcardiac) lobe was included only for the convenience of surgical technic. Because of its unimportance, it is disregarded in the subsequent description.

<sup>6</sup> This served to hasten atelectasis, because of the extremely rapid absorption of oxygen.



Fig 1 Four pairs of dogs' lower pulmonary lobes, giving the size relationships A, C, E, and G, normal, fully inflated left lower lobes (Bracket shows the only inflamed part) B, atelectatic non-inflamed right lower lobe D, F and H, atelectatic inflamed right lower lobes, arranged in order of increasing degrees of the inflammation

was sutured Two hours later, the dog was killed by exsanguination, the chest was opened, the lungs were allowed to collapse, and the right and left lower lobes were removed and measured, one at a time, in a volumetric chamber (2) The left lower lobe was then inflated with air to the approximate size which it had *in vivo* at full inspiration and was maintained so while its volume was measured again The lobes were then cut and examined grossly and microscopically

At autopsy, the right lower lobe of both dogs was found to be liver-color, much shrunk, wrinkled, flabby, and entirely airless (Fig 1-B) The cut surface was the same color, dry, and concave At microscopic examination, the alveoli were found to be completely collapsed, the capillaries dilated somewhat, and the

tissues as a whole free from inflammatory exudate The left lower lobes presented nothing abnormal (Fig 1-A) The volumes of the right lower lobes were 50 and 61 per cent of those of the corresponding left lower lobes when the latter were collapsed, and 85 and 59 per cent, respectively, when the left lower lobes were expanded (Table I)

In brief, the result was that the right lower lung lobes were massively atelectatic, free from inflammation, and very small as compared to the corresponding normal left lower lobes, whether the latter were inflated or deflated

*Group 2 Atelectasis with Inflammation of Various Grades*—Each of the three dogs of this group was prepared for thoracotomy as described above, but the operation itself was changed in that the cannula

was ligated permanently into the bronchus, the ventilation with oxygen was omitted, and all of the lobes were inflated with air before closing the incision. Immediately afterward, 3 c.c. of a concentrated culture of pneumococcus (type 1) in saline was injected through the tube into the cannulated lobes,<sup>7</sup> and the tube was left open. Two hours later, the cannulated lobes were ventilated repeatedly with pure oxygen through the same tube, and then the tube was clamped. Two hours later still, the animal was killed and examined in the same manner as were the dogs of the first group.

The right lower lobes of all the dogs were found at autopsy to be dark purple in some regions and liver-color in others, the extent of the purple discoloration being very small in one case (Fig 1-D), somewhat greater in the second (Fig 1-F), and nearly all-inclusive in the third (Fig 1-H). These lobes were distinctly firmer and heavier than the right lower lobes of the dogs of Group 1, the more extensive the purplish discoloration, the heavier was the lobe. The cut surfaces were moist and flat or slightly convex in the regions of purplish discoloration, and were less moist and slightly concave in the other parts. Microscopically, in some sections the alveoli and interstitial tissues were infiltrated with serum and leukocytes and, in others, the airways were free from exudate, and completely collapsed. There was moderate vascular engorgement; all parts were airless. Two of the left lower lobes were normal (Fig 1-C and Fig 1-E), but one (Fig 1-G), the mate of the most inflamed atelectatic lobe, had a small area of light inflammatory

reaction along the vertebral margin. The volumes of the right lower lobes were 71, 113, and 198 per cent of those of the corresponding left lower lobes, when the latter were collapsed, and 156, 191, and 428 per cent, respectively, when the left lower lobes were expanded (Table I).

In brief, it was found that the right lower lobes were airless, the seat of both atelectasis and acute inflammation in varying proportions, and much smaller than the corresponding normal inflated left lower lobes, although distinctly larger than the atelectatic non-inflamed lobes in Group 1. The size was proportional to the extent of the inflammation, and was either smaller or larger than the corresponding normal deflated left lower lobes.

TABLE I

Experimental data. Group 1 refers to the dogs with atelectasis and no inflammation, while Group 2 refers to those with both lesions. Dog 1 of Group 2 had the least inflammation and Dog 3 the most.

Group	Dog no	Volume of right lower lobe (atelectatic) (c.c.)	Volume of left lower lobe		Relation by volume of right lower lobe to left lower lobe	
			(deflated) (c.c.)	(inflated) (c.c.)	(1 l lobe deflated) (%)	(1 l lobe inflated) (%)
1	1	16	32	191	50	8.5
	2	17	28	286	60.7	5.9
2	1	25	35	160	71.4	15.6
	2	47	41	245	113.2	19.1
	3	107	54	250	198.1	42.8

## CLINICAL SUPPORT

The clinical data demonstrate, by roentgenograms, the relationship in size between the massively atelectatic non-inflamed lung, the massively atelectatic lung with inflammation of various extents, and the air-containing non-inflamed lung at inspiration. In all cases the infection was tuberculous, and in some there were certain amounts of secondary non-specific infection. These cases were chosen because they presented little or no distortion of the organ from adhesions,

<sup>7</sup> The intrabronchial injection of virulent pneumococci in dogs produces very regularly a disease closely resembling lobar pneumonia in man (4, 5, 2, 3). The two are similar in the manner of spread of the lesion, the localization of the process, the immune response, the abrupt termination of the disease by crisis, lysis, or death, and the rapid regression of the process after recovery. With the evolution of the disease the lesion passes through the different stages observed in the human pneumonic lung" (4). In the present experiments, it was desired to produce only the early exudative reaction before killing the animal.

and sufficient clinical data for estimating the extent of the pulmonary infection

*Group 1 Atelectasis with Little or No Inflammation*—S Y H, male, 40 years of age, 40 days before admission, suddenly developed dyspnea, palpitation, and dizziness of a marked degree during a wrestling bout. The dizziness soon left, but the other symptoms persisted in milder form for 10 days. Without apparent cause, the dyspnea began to grow worse so that, from the fifteenth day on, it almost completely incapacitated the patient. Coughing, which came in occasional light paroxysms, intensified the breathlessness. No degree of fever, sweating, or other signs of toxemia appeared. The only pertinent feature of the past history was that each winter for several years a slight productive cough had occurred. Examination revealed a well nourished, slightly dyspneic person. Typical signs of pneumothorax were found on the left, with extensive displacement of the heart to the right. The pulse was somewhat rapid, the temperature and blood counts were normal. A small amount of mucoid sputum, free from tubercle bacilli, was raised daily. Thoracentesis showed air in the left pleural cavity under tension of from 6 to 10 mm Hg, and, when 1,500 cc of the air was withdrawn, the pressure was reduced to approximately that of the outer atmosphere. A roentgenogram (Fig 2), made after this treatment, showed the left lung, which was extremely small, to be collapsed and massively atelectatic, with a long slender adhesion extending from the apex to the vertebral end of the second or third rib. The left hemidiaphragm was depressed, and the heart and trachea were displaced slightly to the right. The right lung appeared normal except for an area of increased density opposite the bulge of the heart, due to pulmonary relaxation. The costo-diaphragmatic sulcus on the right was obliterated.

The pneumothorax in this case was apparently the result of a tear in the visceral pleura, probably near the apical adhesion, and the formation of a valvular

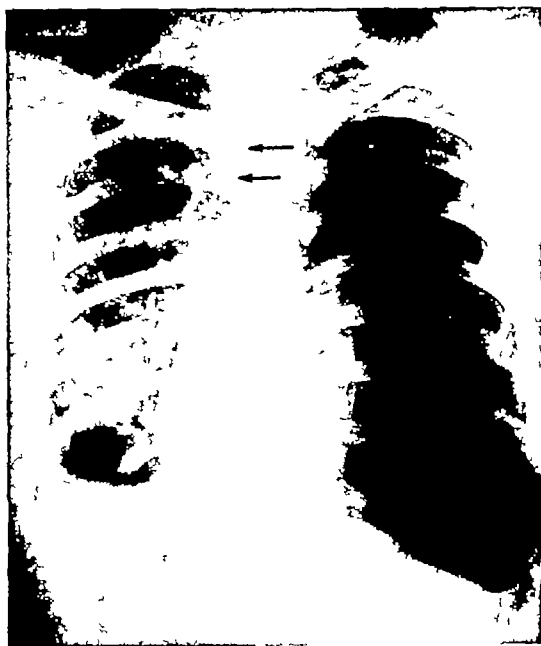


Fig 2 Case S Y H, Group 1 Spontaneous pneumothorax producing atelectasis of the whole non-inflamed left lung. That lung is represented by a small fusiform shadow beside the vertebral column. Arrows, left wall of the displaced trachea.

bronchopleural fistula. The pleural adhesions indicated pre-existing inflammation, possibly tuberculous. The productive cough pointed to an existing bronchitis, evidently non-tuberculous. Judging from the entire lack of symptoms or signs of toxemia at admission, it seemed that the pulmonary parenchyma was free from significant active inflammation. Although the collapsed lung was partly covered by the vertebral column on the x-ray film, the border on that side could be located, from the position of the heart, well enough for estimation of the size. The right and left lungs, as shown by the x-ray film, evidently had about the same relationship in size as the two lobes of the dog (Fig 1-A and Fig 1-B) which were in the same states, respectively, that is, the atelectatic, non-inflamed lung was indeed very small as compared with the fully inflated one.

L J C, male, 30 years of age, was admitted to the hospital for sore throat, cough, and fever of two days' duration.



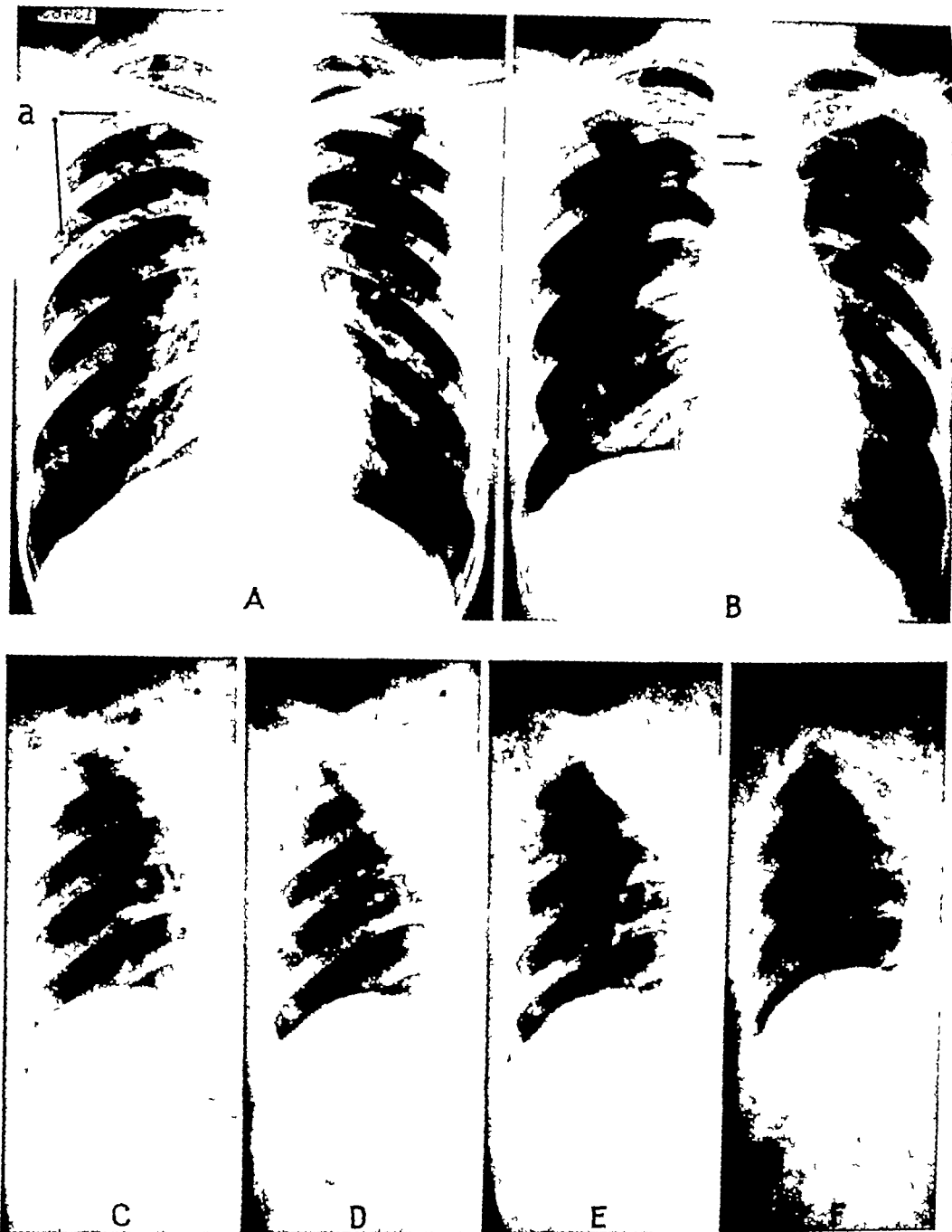


Fig 3 Case L J C Group 1. Atelectasis of the right upper lobe, at times with active tuberculosis and at other times without it. *A* before atelectasis (the tuberculosis is at *a*). *B* during pneumothorax therapy with atelectasis and slight inflammation of the right upper lobe. The lobe is represented by a moderately large triangular shadow in the upper lung field. Arrows, right wall of the displaced trachea. *C, D, E* and *F* right hemithorax only, at monthly periods following the abandonment of pneumothorax and the institution of phrenic block. The lobe is shown as a shadow filling the pleural dome with dots marking for comparison, one diameter in each view. *C* period of quiescent infection and a very small lobar diameter. *D* beginning of new inflammation with a much larger diameter. *E* and *F* period of subacute inflammation with the diameter slightly smaller and constant.

The past history was unimportant. Physical examination showed only the evidences of a severe upper respiratory infection, but a roentgenogram (Fig 3-A) revealed two areas of light infiltration in the right upper pulmonary lobe, and smears of the sputum were found to contain several tubercle bacilli per microscopic field. After the patient had rested in bed one week, all symptoms except a slight cough had gone. Rest was continued and the tuberculosis was treated with pneumothorax. As a result, the right upper lobe collapsed and became completely atelectatic, while the other lobes were partially collapsed and remained air-containing (Fig 3-B). The atelectatic lobe was suspended by an apical adhesion and appeared moderately large. The right hemidiaphragm was slightly elevated, and the heart and trachea were displaced a little toward the left. Low-grade fever having persistently accompanied the pneumothorax, this treatment was abandoned and phrenicotomy was substituted. As a result the patient showed improvement, consisting of increase in weight, and subsidence of the fever, cough, and sputum. An x-ray examination, five months after the disappearance of symptoms, showed that the right upper lobe, which was very small, was still atelectatic although the pneumothorax was absent (Fig 3-C). The diaphragm on that side was elevated and non-motile.

During the period of the pneumothorax, the size of the lobe and the symptoms were in agreement in indicating slight activity of the tuberculosis. The enlargement of the lobe is quite evident when compared with the size of the lobe's roentgenographic field (Fig 3-B), and the size of the field of the entire atelectatic uninfamed lung of the previous case (Fig 2). The bronchus of the lobe probably became obstructed during the pneumothorax and remained so, since the amount of air in the pleural cavity was probably insufficient to produce atelectasis from pulmonary compression alone, and

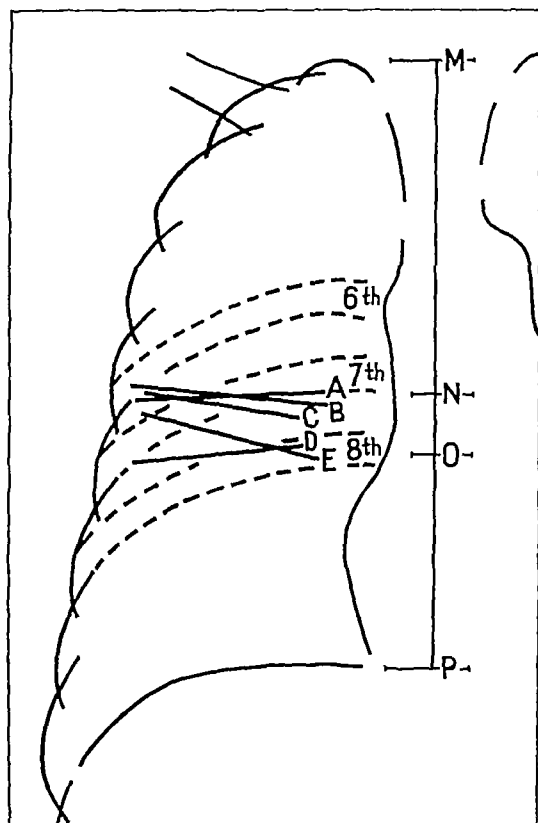


Fig 4 Diagram of the roentgenographic field of the normal right lung in man. A, B, C, D, and E, lines indicating the positions commonly taken by the fissure between the upper and middle lobes. M-P, height of the entire field. M-O and M-N, maximum and minimum heights, respectively, of the upper lobe.

since the lobe failed to re-expand after the abandonment of pneumothorax. The obstruction was probably from cicatrix, this being the commonest form of chronic obstruction in pulmonary tuberculosis. Later, when it was clinically evident that the tuberculosis was entirely quiescent, the size of the lobe was in agreement again. The very small size of this atelectatic, apparently non-inflamed, right upper lobe compared with the normal, fully expanded, right upper lobe is seen by comparing the roentgenographic image of the lobe in Figure 3-C with the outlines of the lobe in the diagram in Figure 4.

The diagram was made compositely from the thoracic roentgenograms of five persons whose lungs were normal and exhibited the fissure between the upper and

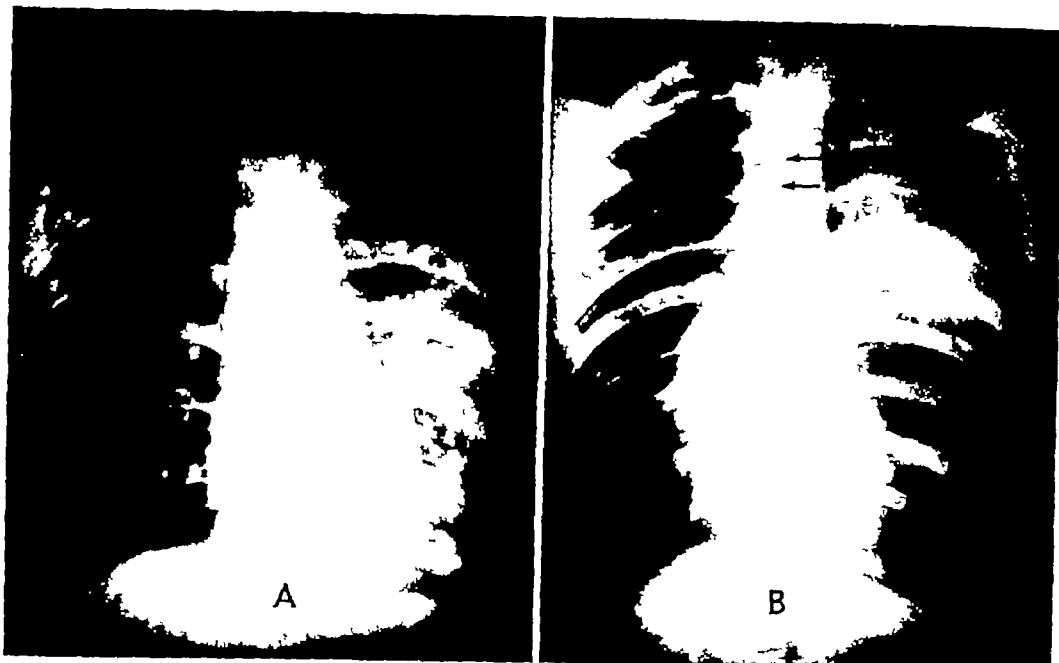


Fig 5 Case S Y D Atelectasis of an extensively tuberculous left lung *A*, before atelectasis *B*, during pneumothorax therapy, with atelectasis The lung is represented by a very large pear-shaped shadow Arrows left wall of the displaced trachea

middle lobes The outlines of the right lung-field, and of the posterior portions of the sixth, seventh, and eighth ribs were traced from one film, and then the locations of the interlobar fissure were added by tracing onto the diagram the lines (Figs 4-A, 4-B, 4-C, 4-D, and 4-E) of the fissures in the five films The height of the lung, *ie*, the distance from the diaphragmatic plateau to the pulmonary apex (*P-M*), was marked out and the levels of the centers of the uppermost and lowermost interlobar fissures (*N* and *O*, respectively) were indicated on the line

Measurements from the diagram show that the right upper lobes of these five normal cases were from 55 to 65 per cent by height, and from 46 to 56 per cent by area, of the entire right lung (The proportion as to height in most cases has been found to hold for the left side also, while the proportion as to area on that side is represented by a larger percentage, because of the cardiac shadow) Now

the area of the roentgenographic image of the right upper lobe in the case that was just described, before atelectasis developed, can be calculated approximately by measuring the area of the entire right lung-field in Figure 3-A, and dividing it by one-half (51 per cent being the average of 46 and 56 per cent) The area of the atelectatic, non-inflamed lobe in Figure 3-C, when measured for comparison, is found to be one-third That is, the atelectatic lobe was reduced to one-third the area it had attained when inflated

*Group 2 Atelectasis with Extensive Inflammation of Various Degrees*—L J C, the patient just referred to, developed, 18 months after the original onset of the illness, an acute upper respiratory infection with cough, high fever, and, for the first time, leukocytosis (11,000 cells per c.c.) several weeks after having been allowed out of bed He was returned to bed at once Roentgenographic examination showed that the atelectatic lobe was

greatly enlarged (Fig 3-D) The upper respiratory infection soon completely subsided, but the cough and leukocytosis persisted, and for periods of from one to two weeks on three occasions during the next four months the patient suffered chills, sweating, high fever, increased cough, and elevated leukocyte count (15,000 to 21,000 cells per c c) There was no return of the upper respiratory infection The sputum was always scanty, mucoid, without offensive odor, and without tubercle bacilli At each recrudescence, a systematic examination revealed no other cause of the symptoms than the disease of the right upper lobe Repeated x-ray examinations showed that the lobe remained enlarged, although there persisted a slight reduction in size which appeared two months after the beginning of the episode (Fig 3-E and Fig 3-F)

It seems certain that the toxemia during this episode, just as during the other period, was due to inflammation of the atelectatic lobe, but the chills and leukocytosis suggested a suppurative, non-tuberculous type of inflammation (The organisms probably entered the lobe, at the beginning of the episode, from the inflamed upper respiratory tract<sup>8</sup>) The bronchial obstruction prevented drainage, with the result that the sputum carried no telltale products of the inflammation and the infection failed to heal The acute inflammation apparently was the cause of the remarkable enlargement of the lobe, and the lapse into chronicity that followed was probably responsible for the slight reduction in size during the last two months

S Y D, male, 32 years of age, complained of illness of eight months' duration with productive cough, hemoptysis, fever, sweating, and great loss of weight Examination showed a poorly nourished

and slightly dyspneic person, with signs of exudative tuberculosis over the whole left lung The pulmonary findings were corroborated by means of the x-ray (Fig 5-A) The sputum was abundant, un-offensive, and rich in tubercle bacilli There was moderate anemia but no leukocytosis The temperature fluctuated daily between 37.5° and 39° C Pneumothorax was instituted and, following three small injections of air, massive atelectasis of the entire left lung appeared (Fig 5-B) The organ was very large and hung from a broad adhesion at the apex The heart and trachea were displaced slightly toward the right, and the hemidiaphragm was moderately depressed The large size of the atelectatic lung seemed to reflect the clinical and roentgenographic impressions, before the atelectasis developed, that the lung was extensively inflamed The organ must have held a great quantity of exudate The large size is especially evident when compared with the atelectatic lung in Figure 5-B, and the atelectatic non-inflamed lung in Figure 2

C S T, female, 32 years of age, was first seen after having been ill for two years with productive cough, hemoptysis, night sweats, marked fever, and progressive loss of weight The upper half of the right side of the chest was contracted, flat to percussion, and with distant breath sounds, while the lower half exhibited resonance and many râles The left side presented no abnormal signs X-rays (Fig 6) showed the right upper lobe to be massively atelectatic and to occupy almost one-half of the right lung-field The lobes below were heavily infiltrated with tubercles but otherwise were air-containing, and the lower part of the left lung showed widespread, very light tuberculous infiltration The trachea and heart were deviated a little to the right, and the right hemidiaphragm was elevated All evidences suggested a very active and widespread exudative tuberculosis

Here again, the great size of the atelectatic lobe appeared to reflect the impression, gained from the other roentgeno-

<sup>8</sup> This is quite possible in spite of the obstruction of the bronchus of the lobe, since the bacteria might well have reached the lobe from above either by way of the peribronchial lymphatics, which is believed to be the regular portal in lobar pneumonia (6), or by the blood stream



Fig 6 Case C S T Atelectasis of the right upper lobe and tuberculosis of both lungs. The atelectatic lobe is shown by a large shadow filling the right upper field. Arrows left wall of the displaced trachea.

graphic and clinical signs, that the lungs were involved by an extensive exudative inflammation. The enlargement is particularly striking when the roentgenographic field of the lobe in Figure 6 is compared with that of the atelectatic non-inflamed lobe in Figure 3-C.

#### CONCLUSIONS

(1) An atelectatic non-inflamed lung is very small in comparison with the fully inflated normal lung (in the dog about one-twelfth, by volume, and in man one-third or less, by area of the roentgenographic image), and also in comparison with the deflated uninflamed lung (in the dog about one-half by volume).

(2) An acutely inflamed atelectatic lung may be considerably larger (in the dog as large as two-fifths, by volume, and in man as large as four-fifths, by area of the roentgenographic image, of the fully inflated uninflamed lung, and in the dog as large as seven times by volume, and in

man as large as three times by area of the atelectatic uninflamed lung).

(3) The increase in size of the inflamed atelectatic lung is roughly proportional to the degree of the inflammation.

(4) Enlargement of the atelectatic lung, as estimated from the clinical roentgenogram, can be used under certain circumstances as a sign of inflammation in the lobe.

(5) All of this applies to massive atelectasis only, either obstructive or compressive, and to any one division of the lung. However, the clinical application of the sign is practicable only with atelectasis involving one or more whole lobes, and not smaller divisions.

#### SUMMARY

Experimental and clinical data are presented to show that, with certain reservations, enlargement of a massively atelectatic lobe of the lungs is a sign of the presence of active inflammation, and that the degree of the enlargement indicates the extent of the inflammation. This sign is adaptable to roentgenographic usage in clinical work and is helpful, particularly when other evidences of existing inflammation are indefinite or lacking.

The experimental data are from dogs, and include accurate volumetric measurements of individual lobes. The data from man give approximate comparative measurements of individual lungs or lobes in terms of the size (area or diameter) of the roentgenographic image. Both the experimental and the clinical data include lungs which are normal, atelectatic and non-inflamed, and atelectatic, while being the seat of inflammation of various extents.

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# THE ADVISABILITY OF IMMEDIATE COLONIC IRRIGATION FOLLOWING A BARIUM ENEMA

ESTIMATION OF SOME OF THE DANGERS ACCOMPANYING THE USE OF BARIUM

By MEYER GOLOB, M D , *New York City*

THE discovery of the utility of opaque substances as a means of visualizing the alimentary tract roentgenographically has been a cardinal factor in the new impetus in gastro-enterology, which has been evident during the last couple of decades. Nevertheless, its development, routine as its use has now become, has not been unattended by occasional upsetting difficulties, unexpectedly covering the attending physician with confusion. Of far more serious significance, they have threatened the well-being of the patient, at times to the point of terminating life.

As with most other important discoveries in medical science, the refinement of the use of roentgenography in gastrointestinal diagnosis has revolved around three problems: (1) the endeavor to find a non-toxic or least toxic opaque medium, (2) the clinical mapping out of contra-indications, and (3) the recognition of possible mishaps, their prophylaxis, and treatment.

*Toxicity of the Medium*—Bismuth, first used as the opaque medium, in spite of its toxicity, was superseded by non-toxic barium sulphate. It was then found through clinical mishap and bitter experience that the substitution in itself was insufficient as a safeguard. It was essential that the insoluble barium sulphate used must be free from contamination with soluble and poisonous barium salts. The poisons of this nature most frequently encountered in clinical practice have been barium chloride, barium carbonate, barium sulphid, barium nitrate, and barium acetate.

Though accidents with barium salts have been comparatively rare, the number of barium meals and enemas given in roentgen-ray work necessitates that the physician shall attend to the purity of the sus-

pension he utilizes. McNally (1), who reviewed this subject in 1925, cited 44 deaths caused by soluble barium salts poisoning, and reported two additional cases. In one of these latter, the physician had erroneously written "barium carbonate" instead of "barium sulphate" in his prescription. The error was not detected by the pharmacist, and the patient died. In the other case, a woman drank barium sulphid in buttermilk, with fatal result. McNally comments on the fact that the barium sulphate given to patients for roentgen-ray examination should be of a chemically pure grade only, should be administered only by the physician who is to make the examination, and that "each lot of barium sulphate should be tested for soluble barium compounds."

On the score of the confusion of the soluble barium salts with insoluble barium sulphate, the U. S. Pharmacopeia cautions: "In prescribing barium sulphate the title should never be abbreviated, to avoid confusion with the poisonous barium sulphide or sulphite." It is axiomatic, too, that as imperative a precaution is necessary with regard to the use of a barium sulphate known to be free of these soluble salts.

*Ulcer Perforation Following Diagnostic Barium*—This is a catastrophe which has occasionally been reported in the medical literature. It has seemed to the physicians reporting the cases that the perforation was due directly to the ingestion of the barium. In Cabot's (2) case No. 15,302, the patient, with acute diverticulitis, suffered a perforation 36 hours after a barium enema. Dr. E. P. Richardson, commenting on this sequence, suggests that it would be well to be conservative in regard to the use of barium enemas when diverticulitis is suspected, and it was further suggested that it would be much safer in these cases

to allow a lapse of two weeks or more after an acute attack before attempting diagnosis with barium

Klein (3), in 1923, Pizzogho (4), in 1927, and Ein Waldt (5), in 1928, reported similar perforations of duodenal, pyloric, and gastric ulcers apparently due to the diagnostic use of barium or bismuth Eckman (6), who, in 1928, reported five cases of acute ulcer perforation following barium meals, observed at the Duluth Clinic, where approximately 1,500 gastro-intestinal examinations are done yearly, recommends that patients with ulcer, in whom symptoms point toward a penetrating type of lesion, should be urged to remain within convenient distance of adequate medical aid or should be hospitalized until the danger of perforation after the barium is passed He considers the following symptoms as contra-indications to all or part of gastro-intestinal examinations bleeding, unusual and increasing severity of distress, epigastric tenderness and rigidity, failure of food to relieve as promptly and completely as previously, night pain in patients previously free of it, and excessive spasm

*Obstruction of the Colon as a Contra-indication*—Williams (7) has recently suggested that, if obstruction of the colon is acute, great care should be observed in making the x-ray examination and that, even with the barium enema, there is some danger in spite of every precaution, the barium meal is, of course, contra-indicated

*Untoward Reactions from Barium in Malted Milk in Cachectic Patients*—Severe gastric distress and grave hematemesis, following barium administered in malted milk, in a cancer patient exhibiting extreme cachexia and achlorhydria was reported by Summersgill (8), in 1924 Levey (8), in a communication to the same publication, corroborated this apparent sequence from his personal observation in several instances "Since then," he says, "I have not attempted the use of malted milk in these cases which exhibit emaciation, cachexia, and achlorhydria

It is evident that there occurs, in the proc-



Fig 1 Case 3, showing partial obstruction due to hardened feces after a diagnostic barium enema This roentgenograph, dated Oct. 29, 1932, shows the colonic tract after evacuation

ess of digestion, fermentation which is of such a type that it cannot be properly controlled by the abnormal gastric and intestinal secretions" He had no difficulty in these cases when he used buttermilk or mucilage of acacia as a base

#### UNDUE RETENTION AND HARDENING OF DIAGNOSTIC BARIUM

It has been stated by some authorities that normally the opaque meal should pass from the colon in approximately 24 hours In my experience, however, a more correct statement would be that it takes 48 hours for the barium meal to be evacuated normally

Out of a goodly number of barium administrations, I have encountered in my practice three embarrassing cases of undue retention and hardening of a portion of a barium enema Since it is a mishap which may be frankly injurious and threatening to the patient, its incidence should be recognized and measures taken for its prevention In the least detrimental of my three cases (Case 1), the x-ray film taken after evacuation of the enema





Fig 2 Same case, showing bariumized obstructive mass in its colonic location thirty six days following the barium suspension study

showed retention of the opaque medium in the entire proximal colon. Sixteen days later, there was a sudden onset of abdominal colic accompanied by obstinate constipation. Fluoroscopy disclosed a shadow at the pelvic rectal junction, evidently caused by hardened bariumized feces. I was able to dislodge the mass by colonic irrigation, and the symptoms subsided without recurrence.

In the second case (Case 2), the barium mixture was visualized in the iliac portion, and was segmented and apparently embedded in the mucosa. The symptom which led to the discovery of the retention was frank bleeding accompanying the bowel movements. The retention of the opaque medium lingered for about three weeks. Final migration, with expulsion of the stony bariumized feces, was accomplished by administration of oil orally and of retention enemas.

The third case (Case 3) presented the most serious aspect because of the symptomatic simulation of a malignant syndrome. The patient, a female aged 59 years, suffered from achylia, in 1927, as was demonstrated by repeated gastric analysis. She did well, however, on HCl therapy. In 1931, she returned to me for a periodic health examination, at which time, the histamine test revealed a true achylia. Because of the onset of constipation, a barium suspension enema was administered diagnostically. Figures 1 and 2 show the colonic tract before and after evacuation



Fig 3 The bariumized mass after its extraction

of the enema. Thirty-six days following this suspension study, the patient presented characteristic symptoms of a malignancy, *i e*, rapid loss of weight, anorexia, asthenia, and a sense of incomplete evacuation on defecation. However, roentgenologically the findings were negative so far as malignancy was concerned. A proctoscopic examination disclosed a clay-colored mass in the distal colon which I could just reach by digital examination, and which presented a stony hardness to the palpating finger.

Recalling my other two cases of long retention of a barium enema, I prescribed colonic irrigation. Seven gallons of water were used and a large amount of mucus and fecal debris recovered. Believing that the bariumized mass had probably been washed away, I prescribed oil enemas to allay the irritation. The patient returned, however, in three days without relief of symptoms. Proctoscopic examination again revealed the mass, which I was finally able to dislodge only through bimanual manipulation intrarectally and intravaginally. Figure 2 shows the mass in its location, Figure 3, the mass as dislodged. Its size corresponds in both of these figures.

#### DISCUSSION

The last case is of special interest because it illustrates the clinical similarity between a simple mechanical obstruction and malignancy. The family physician—quite logically, because of the age and the

symptoms of the patient—had suspected malignancy and was considering the advisability of operation. Fecal impaction, especially at the pelvic rectal juncture in a patient beyond the fifth decade, is always suggestive of malignant growth in the distal colon.

To prevent an experience such as I have described, I now order a saline enema immediately after a barium enema, also oil orally for several days, to insure complete evacuation of the barium suspension. I advocate this procedure as a routine measure following roentgenologic study by means of the barium enema.

A cursory review of the literature reveals that there have been several reported cases similar to my own. In 1923, Klem (3) reported an ileus due to impacted barium sulphate, which developed immediately following roentgenography and was fatal in six days. At necropsy, the stony concretions were found to measure  $2.2 \times 1.4 \times 1.2$  cm, and had lodged in the sigmoid flexure. He cited two other instances of calculus formation. In Schwarz's case, the barium sulphate concretion was pushed along and voided spontaneously by giving more of the suspension. In Kummatt's case, bismuth was used and had piled up as a hard mass in the stomach, raising the question of the safety of administering contrast suspensions in the presence of pyloric stenosis. Orgel (9) reported a case, in 1929, of a partially retained barium meal simulating intestinal obstruction. High rectal washings of oil, water, and peroxide were administered. Oral administration of large amounts of mineral oil and gentle kneading finally cleared the colon of the bariumized material. Orgel emphasizes the fact that, in individuals with atonic bowels, care must be taken as to the amount of barium given and also as to observation

of the facility of its passage through the colon. Also, in 1929, Révész (10) reported the retention of barium in the intestine for 43 days.

## CONCLUSIONS

1 The mishaps sometimes, though not frequently, encountered in the use of barium sulphate in gastro-intestinal diagnosis include accidental poisoning due to impurity of the drug, ulcer perforation due to the drug, and undue retention and hardening of the opaque medium causing symptoms or obstruction.

2 Three cases of the latter are presented, and the literature reviewed briefly.

3 The author advocates the routine administration of a saline enema immediately after a barium enema, also oil orally for several days, to insure complete evacuation of the barium suspension.

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# A METHOD TO RENDER RADIORESISTANT TUMORS RADIOSENSITIVE<sup>1</sup>

By M J SITTENFIELD, M D , *New York City*

TUMORS which react favorably to radiation are termed radiosensitive, on the other hand, malignant growths which seem stubborn to radiant energy are looked upon as radioresistant. There are, however, so many exceptions and irregularities to these two classifications that definite grouping is quite out of the question. The fact that a tumor which reacts poorly to x-ray and responds favorably to the gamma rays of radium, and *vice versa*, opens a wide field for discussion. So, too, there are instances in which a tumor does not react well with one particular technic, but behaves like a radio-sensitive tumor when another technic is substituted.

These peculiarities raise the question, whether a proper appraisal of the type of tumor and the type of radiant energy employed may not play an important part in changing the character of a so-called resistant neoplasm to one which becomes subsequently sensitive to radiation.

If the degree of malignancy of a given tumor and the degree of radiosensitivity were definitely established, then it would be an easy matter to correlate one with the other. Although we have not up to the present time reached this ideal, there have been, nevertheless, many facts established which have not only advanced our knowledge of radiant energy, but also of the pathologic changes occurring in the tumor.

Radiosensitivity, even of the most sensitive type of tissue, does not mean a constant or a fixed condition. It is very well understood that graded doses of radiant energy are followed by different reactions in radiated tumors. A small dose of radiation stimulates the function of the cell, a larger dose suspends or retards the ac-

tivity of the cell, while an intense dose destroys the cell by a caustic-like action. It is the quality and quantity of the intensity of the radiant energy which determine the reaction in the cell, although the changes taking place within the cells are by no means alike, since they vary even in cells of the same type.

To appreciate the radio-biologic events which take place in a cell or a tissue, it is necessary to bear in mind that the effect of radiation in a tissue is the result of a primary and a secondary reaction. The primary, or temporary, effect may be so slight as to be followed by complete recovery of the cells, the secondary, or latent, reaction, especially if the dose is intense, may injure the tissue so severely that the destruction produced will have gone beyond the stage of repair. The reaction which follows a definite dose of radiant energy can very well be compared to the effect produced by drugs when used in small, moderate, or large doses.

To emphasize this again, the reaction which takes place in the radiated tumor depends upon (1) the type of radiant energy employed, (2) the physiologic and biologic state of the cancer cell, and (3) upon the maintenance of the healthy and surrounding tissue. In other words, the effect of a sublethal dose of radiation is quite different from the destructive result which follows an intense dose of gamma radiation. Therefore, the radiant energy should be so employed that the amount administered bears a definite relation to the biologic effect desired, since variation in dosage results in different reactions.

From these facts, it becomes apparent that the therapeutic dose of radiation does not aim only to destroy the tissue, its chief purpose is to prevent further multiplication of the cancer cell and at the same time to stimulate the defensive

<sup>1</sup> Read before the American Congress of Radiology at Chicago Sept 25-30, 1933

mechanism in the adjacent healthy tissue in the arrest of the malignant process

The radio-biologic reaction, then, consists of a direct and a latent process, and it is the combined action of the two which exerts a decided influence upon the healthy surrounding tissue. This defensive mechanism of the neighboring healthy tissue, called by some the "anticarcinomatous reaction," plays perhaps the greater and more important part in the radio-biologic reaction following a suitable dose of radiation. However, following an intensive dose of radiant energy, not only are the malignant cells destroyed to a great extent, but the surrounding tissue itself suffers such severe injury that it thereby sacrifices its defensive mechanism and tissue resistance.

On the basis of recent experiments which will be spoken of later, the defensive mechanism of the adjacent tissues is shown to be of greatest importance in the regression and disappearance of the tumor. Along the same line of investigation, these experiments showed that a carefully selected dose of radiant energy paralyzes the reproductive property of the cancer cell and in this manner impairs the multiplication of the cell without destroying it. A cancer cell which does not multiply any further is no source of danger, especially if the indirect effect of the radiation upon the adjacent neighboring tissue exerts its anticarcinomatous action upon the tumor itself.

This, after all, is the ideal therapy and brings into the foreground the question: When and how are we to take advantage of the most radiosensitive stage of the cancer cell? It is pretty well accepted that the phase preceding and during mitosis of the cancer cell is the most sensitive for radio-biologic attack. Experimentally it has been shown in tissue culture work that the growth of normal cells exceeds that of cancer cells, while the number of mitoses of malignant cells outranks that of normal cells. With transplantable tumors it is feasible to establish uniform experimental conditions, which can be repeated at will.

Cramer and other cancer workers report that a sublethal dose of radium, which under ordinary conditions is quite insufficient to destroy cancer cells, will induce complete disappearance of a tumor.

On the other hand, when the tumor is excised after radiation and a new environment is provided by transplanting it into another part of the body, the tumor cells quickly recover from the radiation effects and resume their former rate of growth. This resuscitation of the tumor cells may be observed for three or four days after radiation. In other words, the disappearance of the tumor is not wholly due to the injury of the tumor cells themselves, since they received only a sublethal dose, but to the secondary effect of the surrounding tissue.

Moreover, by inoculating a tumor into each flank and radiating only one tumor, protecting the other flank with lead, the local effect of the tissue resistance is again demonstrated. The radiated tumor regresses, while the tumor in the opposite flank continues to grow as in a normal animal. In other words, it shows definitely that the anticarcinomatous reaction takes place in the surrounding tumor bed and not in the tissues distant from the radiated area. Clinically, this statement can be substantiated as I have never seen the slightest reaction in a metastatic tumor when the primary tumor is irradiated.

This now brings us to the main point of this discussion. It is perfectly true and generally accepted that the greater the number of cells within the tumor undergoing mitosis, the greater is the degree of radiosensitivity of the tissue. This suggests again that the cancer cell is particularly vulnerable to radiant energy during the mitotic phase.

The basis, then, for efficient radiation in the so-called resistant tumors is the excitation of the cancer cells to greater mitotic activity in order to render them particularly sensitive to x-ray and radium. This means the use of small or non-destructive dosage of radiation, remembering that the purpose is to stimulate the

physiologic functions of the cell. By raising the metabolic and biologic functions of the cell, especially in the case of the cancer cell, this tissue becomes increasingly sensitive to the radiant energy and, being stimulated to its greatest activity, becomes exhausted and finally ceases to function entirely. Following this exhaustion or devitalization of the reproductive process of the neoplastic cell, the anticarcinomatous reaction of the surrounding tissue offers active resistance to the progress of the malignancy and subsequently favors the development of the fibroblastic elements. It is of importance to note, however, that each reaction occurs in sequence and culminates at the proper time. In other words, the greater the number of cells within the tumor which are in the phase of mitosis, the more sensitive will be the tissue, also, the longer the intervals between phases of mitosis, the longer will it be necessary to expose the tissues to radiation, if all the cells are to be destroyed selectively. For radiation to be selective it must devitalize and sterilize the cancer cells in doses which do not damage or injure the neighboring unaffected tissues.

It frequently happens that a certain type of cancer might be radiosensitive when localized in one part of the body, and radioinsensitive when growing in another region of the anatomy. This raises the question of whether or not the difference in reaction

is due to one particular technic or to the difference in the anatomic topography, and so forth.

In one case, it may be the tumor bed which offers an indifferent soil to the application of the radiant energy, in the other, the anatomic position in which the tumor lies.

It is not my intention in this discussion to point to the many exceptions which favor or resist the best efforts of radiotherapy. However, I wish to draw attention to the possibility of changing, at times, a so-called resistant tumor to a radiosensitive one by means of exciting mitotic activity. In another publication, I have reported several cases which responded favorably to this method and, while I do not claim that every tumor will respond to this method, it seems to me that it deserves at least a trial when other means have failed.

#### CONCLUSION

I hope that this will dispel the often repeated and unwarranted belief that small and stimulating doses of radiant energy accelerate the growth of a malignant tumor and are therefore contra-indicated. On the contrary, the technic described in this paper has served me satisfactorily to render a tumor, which at the time seemed resistant, to one which behaved subsequently radiosensitive.

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## THE EARLY DIAGNOSIS OF CARCINOMA OF THE COLON, ROENTGENOGRAPHICALLY CONSIDERED<sup>1</sup>

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From the Department of Gastro-enterology, University of Maryland, and the Department of Roentgenology, Sinai Hospital, Baltimore

CARCINOMA of the colon has long been a subject of much interest to both the internist and the surgeon. Though it is not an uncommon affection, unfortunately the diagnosis is too often not established until late in the course of the disease. The onset is so insidious that frequently medical advice is obtained only when therapeutic measures no longer suffice in accomplishing a complete cure. In many instances months may elapse between the onset of the disease and the time when surgical aid is seriously considered. It is a well established fact that a large number of the growths can be removed and permanent cure brought about if surgical measures are instituted at an early period. The difficulty arises in that tumors in the colonic region are slow in their growth, metastasize late, and, consequently, produce few or no symptoms in their early stages. Thus they are overlooked until complications arise that point to their true nature. It is on this account that every possible attempt should be made to arrive at an early diagnosis, especially since cancer of the colon is of rather frequent occurrence. Intestinal carcinoma occupies the fourth place in frequency as to site of malignant growths, being surpassed in numbers only by the stomach, uterus, and breast.

For the purpose of this study the records of 50 cases of carcinoma of the colon have been reviewed. In these, complete clinical as well as roentgenologic studies were made. Growths occurring below the recto-sigmoid area are not considered.

It is my desire to point out the value of x-ray examinations as a means of ar-

riving at an early recognition of this disease. Whenever an individual past middle life, often in the midst of good health, with little or no previous intestinal disturbance, manifests local or general discomfort in the abdomen, associated with disturbances of the bowel in the nature of intermittent or progressive constipation, the possibility of cancer should be suspected and careful investigation should be carried out. A thorough analysis of the history, examinations by digital, rectal, and proctoscopic methods, together with stool investigations, should be made. Early x-ray investigation should never be omitted. Though in the early stages the history and clinical examination are of the greatest importance in pointing to the possibility of this disease, the x-rays may, even at this period, present most definite evidence of its actual presence. This occurs in quite a fair proportion of instances, though it is only fair to state, that, in my experience, occasionally evidence of an early growth was lacking even following roentgenographic examination.

In this series of 50 cases of carcinoma of the colon the growth was observed to be localized as follows: cecum, four cases, ascending colon, three, hepatic flexure, nine, transverse colon, eight, splenic flexure, four, descending colon, three, and sigmoid, nineteen.

In the early period, when the condition is in its incipency, the diagnosis is often most difficult and even in a fair proportion of such instances the x-ray examination may be misleading. It is important to carry out repeated roentgen studies, especially in doubtful cases. A single roentgen examination should not be relied upon as final. However I would like to empha-

<sup>1</sup> Read before the Baltimore City Medical Society, Dec 15, 1931.

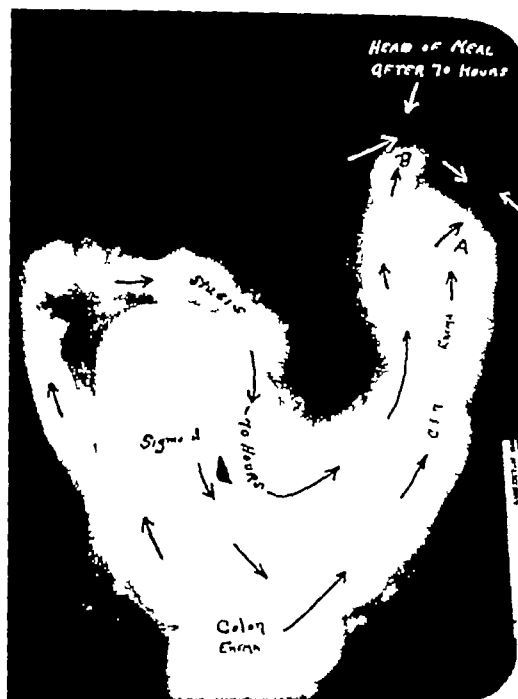


Fig 1 The combined 70 hour colon stasis and colon enema. The head of the progress meal is seen after 70 hours at the splenic flexure (B). Colon enema showed a carcinomatous obstruction in the descending colon below the splenic flexure (1).

size again, at this point, that x-ray evidence of carcinoma in many instances may be elicited long before the clinical manifestations are sufficient to warrant a definite diagnosis.

While it is recognized that the roentgen-ray examination is most important as an aid in arriving at an early diagnosis, we must not be unmindful of the possibility of its errors and limitations. There are often many technical difficulties which may render the diagnosis uncertain and one must exercise great care in evaluating the findings. In certain areas of the colon, especially in the pelvic portion and at the flexures, it is quite possible to overlook a small filling defect, inasmuch as these segments may be obscured by other loops of the bowel. In addition to performing repeated x-ray examinations, it may become necessary to take advantage of special roentgen methods, *viz*, stereoscopic, oblique, and upright views, which frequently

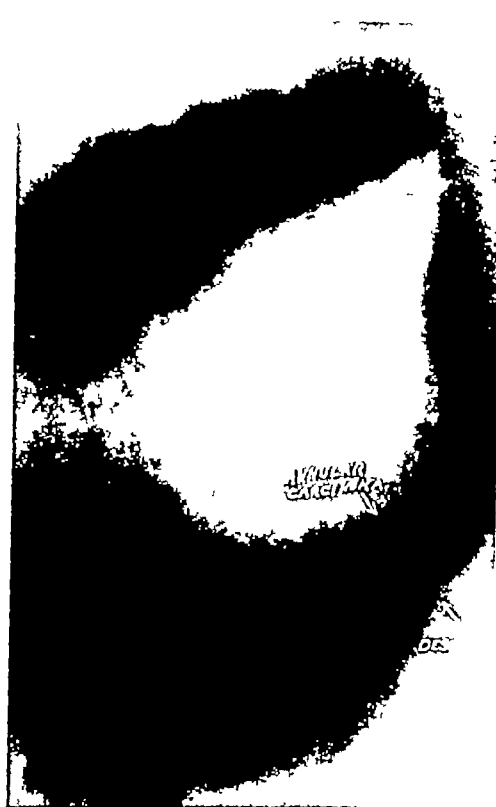


Fig 2 Colon enema demonstrated an annular carcinoma in the lower descending colon.

afford the best and most distinctive evidence of the existence of a growth. Negative findings, however, are of little value, in such instances a repeated study at some future date is usually indicated.

The roentgen picture depends in a great measure on the type of lesion, its size, location, and its complications. There are essentially three roentgen methods which are utilized to determine the presence of a colonic growth: (1) the barium colon enema procedure, (2) the combined barium colon enema and air insufflation, (3) the routine gastro-intestinal 24-hour progress meal.

#### COLON ENEMA

The colon enema, which is usually the method of choice, furnishes the most reliable diagnostic data. It demonstrates the characteristic filling defect produced

by the growth and presents an exact picture of the site, size, and extent of the lesion. It is also invaluable in demonstrating the presence or absence of diseases of the colon other than carcinoma. For this reason it becomes doubly helpful in considering the problem of differential diagnosis.

*Preparation of the Patient*—Most roentgenologists prefer to have the patient properly prepared for the examination of the colon. Castor oil may be given 36 hours before the examination, followed in the evening by a cleansing enema. I believe this is an important detail as a routine measure. Some prefer to examine the patient without any previous preparation, inasmuch as such treatment may produce a hypersensitiveness of the bowel, preventing the retention of the enema. In my experience the omission of the morning cleansing enema results in a more satisfactory examination.

The necessity of having a properly prepared medium for the colon enema cannot be too strongly stressed. The barium should be uniformly suspended, of thin liquid consistency and of proper body temperature. Of importance, too, is the rate of flow into the colon. It is essential that it be slow and that it be administered in small amounts, so that each portion of the bowel may be examined with painstaking care under the fluoroscopic screen.

The normal colon does not fill as a straight tube, it will show many contractions, haustral outlines, and bends at the flexures. There are usually temporary delays at the rectosigmoid junction, at the splenic flexure, at the hepatic flexure, and in the ascending colon above the ileocecal valve. A temporary delay in the passage of the column should be carefully visualized and the area palpated with the gloved hand. On account of the frequency of carcinoma involving these areas, the possibility of a small annular growth, which may be palpable, should not be overlooked. A small constricted area, which often may be confused with spasm, is not an infre-



Fig 3 The 24-hour progress meal revealed a stasis, with the head of barium at the hepatic flexure. The colon enema demonstrated a carcinomatous obstruction at the hepatic third of the transverse colon.

quent finding in the early stages. The necessity of methodically examining each segment of the bowel independently and palpating each area under the screen is important in the examination of the colon. This procedure cannot be too strongly emphasized.

*Filling Defect*—The filling defect varies in size, shape, and regularity, according to the type of carcinoma. It may be small and annular, simulating spasm. It may be smooth and regular, producing a deformity simulating a ring or it may be large and irregular. At times the roentgen defect appears larger than the size of the tumor, due to inflammatory reaction of the surrounding tissue or to a mass of impacted feces. On the other hand it may appear small, yet at operation the neoplasm may be found to be quite large. In the early cases a small narrowed constriction may be interpreted as a haustral contraction. A point of importance, which heretofore has received but little consideration, is a tender area directly above the affected bowel. It is usually localized, persistent, and frequently directs attention to a small filling defect which otherwise might be overlooked. It is of importance to bear in mind that constrictions and organic contractions are not in any way affected by antispasmodics.



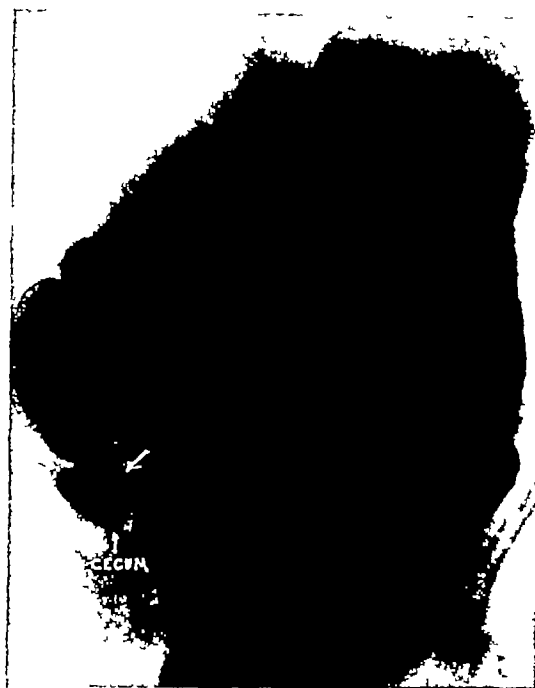


Fig 4 Colon enema showed a carcinomatous filling defect in the cecum



Fig 5 The 12-hour progress meal in the same case, showing the carcinomatous filling defect to be more extensive than that observed in the colon enema film. A large carcinomatous mass is also noted directly above the hepatic flexure at arrows

**Palpable Mass**—A palpable mass co-existing with a filling defect is an important sign of the presence of a tumor. Occasionally a mass may be palpated before a demonstrable filling defect is detected. This type of case may escape the roentgenologist's attention. The mass, however, may be the result of a fecal impaction or an associated inflammatory reaction, the cancer growth itself being small in size.

**Obstruction**—Obstruction, which may not be observed in the early stages, may be partial or complete. It is usually a late manifestation, occurring most commonly on the left side. In the early stages of the disease, no distention of the bowel is observed, in the late stage, the lumen becomes markedly distended proximal to the growth. The presence of an irregularly distended bowel should direct suspicion to a possible tumor.

**Stasis**—Stasis in the colon is observed with great frequency. It may be due to one of many conditions affecting the in-

testinal tract, the majority of which are benign in nature. When it is present, however, to a more or less marked degree in the 24-hour progress meal, it should be viewed with suspicion. In our series the finding of stasis led to further investigations of the colon which finally resulted, in many instances, in a definite diagnosis of carcinoma. In the late stages of the disease, fixation of the affected colon, perforation, and other complications may be encountered.

#### AIR INSUFFLATION

Air insufflation of the colon, reported many years ago by Fischer (1), utilizing the combined air and barium enema, and more recently emphasized by Gershon-Cohen (2), and Weber (3), has become a useful procedure in the examination of obscure colon conditions. In the early mucosal lesions it is possible to obtain valu-

able information by this method, which may often result in a definite clue as to the diagnosis. In the later stages of the disease it is also helpful in rendering a clearer and more distinct view of the tumor. Again it is well to take advantage of this method in those instances in which the loops of the bowel are overlapped. Air insufflation may at times reveal a tumor mass, when the usual opaque barium enema may overshadow it.

This procedure is carried out under the fluoroscopic screen. Following the introduction of the barium enema, a film is immediately taken, the patient is then allowed to expel the contents, when another film is made. The patient is further instructed to expel as much of the remainder as possible, and then air is insufflated into the colon. When the bowel is well filled with air, a film is taken for detailed study. I have found this method a most useful procedure in the examination of the colon in those instances in which small growths are suspected.

#### ROUTINE 24-HOUR PROGRESS MEAL

Barium administered by mouth, as is done in the routine gastro-intestinal progress examination, is sometimes useful in casting further light on the colonic condition. The procedure should always be performed unless some contra-indication exists. The combined progress meal in addition to the barium enema may be of even greater diagnostic aid than either alone. In my own experience one should not place too great reliance upon the colonic findings following the progress meal, unless it is followed by the other procedures. The uneven distribution of the barium throughout the colon may lead to erroneous interpretations. However, at times this procedure gives a clue as to the presence of a possible tumor. This method of examination will not only occasionally reveal a filling defect, but will also outline the proximal site of the tumor, as well as determine other associated conditions of the gastro-intestinal tract.

The presence of a filling defect in carcinoma of the bowel is usually characteristic, but occasionally cancer may be simulated by other conditions. Thus an insufficient amount of barium, fecal matter, spasm, pressure, extrinsic tumors, adhesions, and gas may all produce defects which may mimic carcinoma. These may readily be eliminated by careful technic, cautious interpretation, and by repeated roentgen studies.

In some instances roentgenograms should be obtained in the upright as well as in the prone and supine positions. Stereoscopic and oblique positions are also at times invaluable in demonstrating the true nature of the defect. Hodgson (4) advises the dual exposures for the detection of the filling defect in carcinoma of the bowel. This procedure is carried out by taking two exposures on the same film at two- or three-second intervals.

#### DIFFERENTIAL DIAGNOSIS

The differential diagnosis between carcinoma of the bowel and other lesions simulating it is at times extremely difficult. Numerous conditions may simulate this affection but none produces the typical filling defect, so constantly present and characteristic of carcinoma. The following important conditions must at times be eliminated: diverticulosis, tuberculosis, benign strictures, benign tumors, impacted feces, adhesions, polyposis, localized ulcerative colitis, and intestinal stasis.

In our series of 50 cases, 30 tumors were surgically removed. Of these, the diagnosis was confirmed by both surgical and pathologic studies. In 20 cases the diagnosis was reached by clinical and roentgenologic studies.

#### CONCLUSIONS

I have been impressed with the importance—the necessity—of repeated roentgenologic colonic investigation by a number of cases in this series. The roentgen

examination will reveal essentially two main signs which are significant of a new-growth of the bowel, *viz*, filling defect and obstruction. The filling defect is characteristic in most instances and a diagnosis of carcinoma may be made from it alone. On the other hand, one must make certain that the defect is persistent and that other conditions simulating carcinoma are eliminated. A localized tenderness elicited over a defect is another fairly constant sign suggesting the presence of this lesion. Obstruction is a late manifestation. More often, in the early cases, a retardation to the flow of barium, or canalization of the lumen of the bowel by the growth, or stasis, may be observed. The presence of a palpable mass may not be elicited until late in the course of the disease. The mass is frequently palpated in the area recognized as that of the filling defect. However, the growth may be palpable at times, while at other times it may not. This shifting of the tumor mass is quite characteristic of a colonic new-growth. The necessity of painstaking care in methodically examining each segment of the bowel and the importance of allowing the barium to flow into the colon

at a slow rate during the fluoroscopic examination cannot be overemphasized.

The x-ray investigation of the bowel has not been accorded the importance it deserves, it is too often neglected. Roentgenographic examination clearly demonstrates the presence of the lesion, the location, and the degree of involvement. It is also important to bear in mind that much of this detail is not observed following the routine gastro-intestinal examination alone, therefore, many cases of carcinoma of the bowel are overlooked in the early stages. A routine barium enema should always be given whenever the bowel presents evidence of dysfunction.

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## ROENTGENTHERAPY IN METASTATIC BONE CANCER, WITH REPORT OF FOUR CASES<sup>1</sup>

By J ROEMER, M D , *Paterson, New Jersey*

**T**HAT metastatic bone cancer responds well to high voltage roentgen irradiation is a well-known fact, and there is ample literature to substantiate that view. The foci of bone destruction may be regenerated with new bone formation, which may bring about, in turn, a restoration of normal function to the parts so affected. The patients usually become free of pain within a few days after the treatment has been instituted.

My experience has been confined almost entirely to bone lesions secondary to carcinoma of the breast. I have had occasion to treat only two cases of bone metastases secondary to prostatic cancer, but, in the latter cases, the results were not so good as in the former. I may add that both cases of bone metastases from carcinoma of the prostate had inoperable prostatic tumors. All of the cases which I am presenting were observed in women in whom metastatic bone cancer occurred after radical operation for breast cancer. In these cases there were pronounced bone lesions, as demonstrated by roentgen-ray examination. Undoubtedly more lasting results could be obtained if such cases were treated before metastatic foci are to be roentgenologically demonstrated. In substantiation of this, I wish to cite the case of a woman who developed severe pain in the left hip about one year after mastectomy for carcinoma. Roentgen examination revealed no evidence of any bone pathology. A clinical diagnosis of sciatica was made by the attending physician, and the patient was advised to try spa treatment. Nevertheless pain persisted and nine months after the onset of symptoms, roentgen examination revealed a metastatic focus in the left ischium.

Metastatic foci may also be present in

bones without giving any clinical manifestations. It is, therefore, a wise procedure to make routine roentgen examinations of the skeletal tissues, particularly of the pelvis and spine, in all cases of breast cancer. The cases presented here will illustrate what may be accomplished with roentgentherapy.

Case 1 (Figs 1-3) Mrs E H C, married, aged 41 years, had, in February, 1926, a radical amputation of the right breast for carcinoma. She received no pre- or post-operative radiation. About six months after operation, pain which grew progressively worse, developed in the right hip. On March 18, 1927, the patient came under my observation. Roentgen examination revealed a metastatic lesion involving the right pubis and ischium. She was emaciated, had lost 40 pounds in weight, and was unable to walk. The pelvis was cross-fired with high voltage roentgen radiation, an erythema dose being given to each of three portals of entry. The entire series was given in six successive days. The patient returned for a second series on July 7, 1927. At this time she was feeling well, had regained normal weight, and was able to walk. A roentgenogram taken at this time showed considerable bone regeneration of the focus in the right pubis and ischium. There was a small metastatic focus in the left ischium, which remained quiescent for a period of over three years. Roentgen studies were made at frequent intervals, showing continuous improvement. Twice in 1929 and 1930, the patient received additional small doses (one-half of an erythema dose to each portal). About a month after the first series of roentgentherapy, the patient resumed her occupation as a school teacher and continued until the Fall of 1930. On Oct 18, 1930, she fell down several steps and sustained a pathologic fracture of the right acetabulum. At this time,

<sup>1</sup> Read before the Radiological Society of North America at the Eighteenth Annual Meeting, in Atlantic City, Nov 28-Dec 1 1932



Fig 1



Fig 2

there were also demonstrated metastatic foci in the left ischium and hip. She went to bed, became very despondent, refused nourishment, and died Jan 1, 1931.

Case 2 (Figs 4 and 5) Mrs P N, married, aged 46 years, had, in March, 1925, a radical amputation of the right breast for carcinoma. In May, 1925, the patient was referred to me for post-operative roentgen radiation, which was repeated in November, 1925. On Dec 6, 1926, the patient reported at my office, stating that for the past two months she had had pain in the right hip and was unable to walk without support. Roentgen examination demonstrated metastatic foci in the right ilium and hip. A series

of high voltage roentgen radiation was given, and repeated in February, 1927. When the patient reported for the second series, she was free of pain, had gained weight, and was able to walk. Roentgen examination showed retrogression of the lesions. In the Summer of 1927, she returned to her home in Belgium. I received several post-cards from her, the last in December, 1930, telling me that she felt well.

Case 3 (Figs 6 and 7) Miss M L, single, aged 39 years, had, in September, 1924, a radical amputation of the left breast and, in March, 1927, a radical amputation of the right breast for carcinoma. She received no pre- or post-operative radiation after the first amputation. Five weeks after the second breast was removed, she was referred to me for post-operative radiation, which was carried out. On May 17, 1928, a second course of post-operative radiation was given. At this time there were metastases in the left cervical and supraclavicular glands, to which massive doses of high voltage radiation were applied. On July 19, 1929, the patient complained of pain over the sacrum. Roentgen examination demonstrated a metastatic focus in the sacrum to which high voltage roentgen radiation was given. On Aug 19, 1929, she reported at my office complaining of pain in the left hip, was limping considerably, and found walking quite painful. She had lost 15 pounds in



Fig 3



Fig 4

weight Roentgen examination revealed a metastatic focus in the left femur to which high voltage radiation was given. On Jan 28, 1930, additional smaller doses were applied to both foci, and these were again repeated on Sept 30, 1930. Roentgen examination made after treatment showed bone regeneration in both foci. In the Summer of 1931, the patient's health began to fail and she died in July.

Case 4 (Figs 8 and 9) Mrs M. M., married, aged 36 years, had, in November, 1927, a radical amputation of

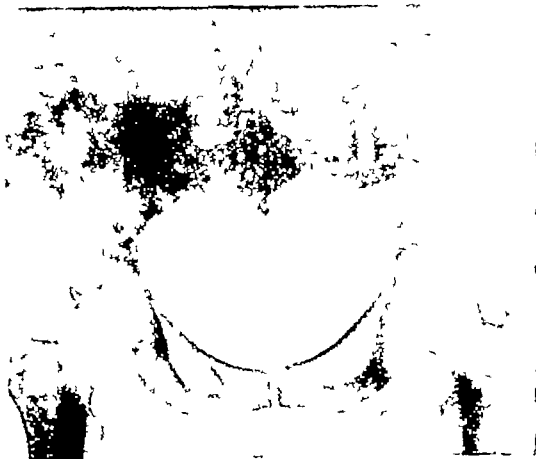


Fig 5

the left breast for carcinoma. On March 3, 1928, the patient was referred to me and one course of high voltage post-operative radiation was given. In May, 1929, I was requested to make a portable x-ray exami-



Fig 6



Fig 7



Fig 1



Fig 2

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Fig 3

are made quite comfortable, are able to perform their household duties, and life can be prolonged for several years. Much better results might be accomplished if such cases were subjected to roentgen radiation as soon as clinical symptoms presented themselves, in spite of negative x-ray findings.

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Fig 8



Fig 9

nation of the lumbo-sacral region. The patient had then been bedfast for three months and it was necessary to give her large doses of morphine for the relief of pain. She had lost over forty pounds in weight and her general condition was very bad. Only an anteroposterior roentgenogram was made of the lumbosacral spine as the patient could not be moved to a position for a lateral view. The roentgen examination revealed extensive metastases to the sacrum and fifth lumbar vertebra. On June 22, 1929, she was brought to my office in an ambulance, and, because of the difficulty in moving her, the entire treatment was given in four sessions, four days apart. She received large doses of morphine in order that she might endure the ordeal of being moved. On Aug 26, 1929, the patient returned for further treatment, and, to my surprise, she was able to walk, had regained over twenty pounds in weight, and felt quite well. Roentgen studies made on that day showed complete bone regeneration of the affected parts. She was given additional small doses in October, November, and December of 1929.

When the patient visited my office on Oct 15, 1929, she informed me that she felt very well and was able to do her house work. She continued thus for over a year, but later developed diabetes mellitus and died in October, 1930, in diabetic coma.

#### TECHNIC

The technic used is as follows: 215 K V, 4 ma, filtered with 0.75 mm Cu and 1 mm Al, at 50 cm focal skin distance. With these factors the erythema dose is 86 minutes, when using a portal of entry 20 × 20 centimeters. Daily treatments are given, if possible. In most instances one-half of an erythema dose is given to one portal of entry at each session. I have encountered very little roentgen sickness in the treatment of metastatic bone lesions.

#### CONCLUSION

These cases demonstrate that metastatic bone cancer responds favorably to high voltage roentgentherapy. The patients

ammeter readings for the various milliamperage factors are likewise on view. The graph is then pasted upon the glass face, and protected by transparent celluloid film. This has proven a neat and practical time-saving device.

### DETERMINATION OF THE POTENCY OF X-RAY DEVELOPER

By GEORGE C. HENNY, M.S., M.D., *Philadelphia*

From the Department of Radiology, Temple University Medical School, Philadelphia

Deterioration of x-ray developer is nearly proportional to the number of square inches of

film developed. A simple method for estimating this deterioration is to keep account of the amount of film developed. Charts to be used in the dark room for this purpose are available and the method is recommended by photographic material manufacturers.

R. B. Wilsey (1) recommends a method which makes use of the fact that the time of development bears a definite ratio to the time required for the image to appear after the film is first immersed in the developer. This ratio is known as the Watkins' factor. Pieces of film which have been exposed over part of their surfaces are developed in a tray, measuring the seconds to the first appearance of the image.

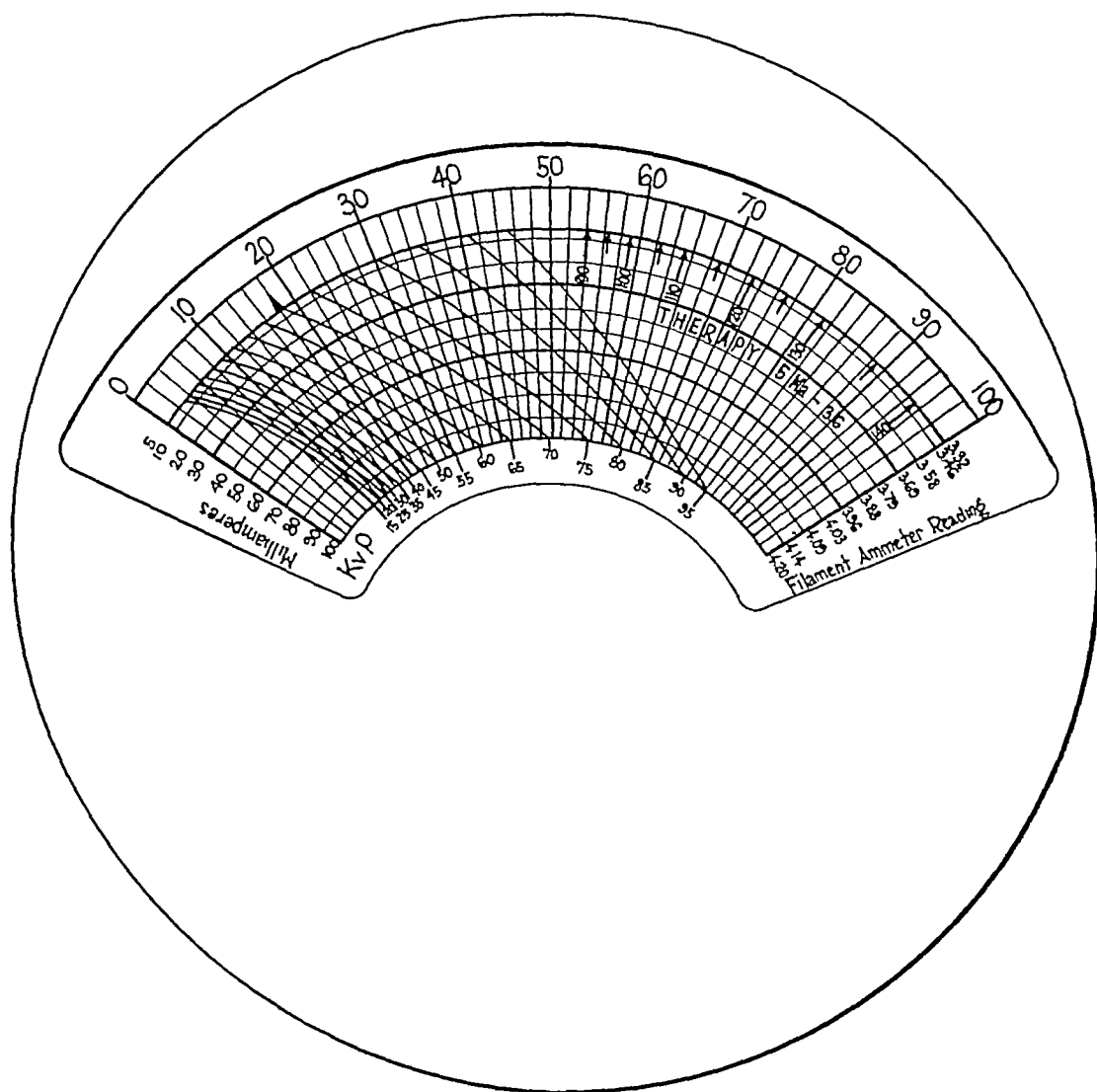


Fig. 3 Calibration chart pasted upon the glass face of the prereading voltmeter. Note the indicator at 18, which is an equivalent to the kilovolt peak readings of 65 for 5 milliamperes, 57 for 30 milliamperes, 38 for 100 milliamperes, etc., with the filament ammeter readings at 3.32, 3.69, 4.20, etc., respectively.

## TWO PRACTICAL RADIOLOGIC SUGGESTIONS

By WILLIAM ROBERT STECHER M D Darby  
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Department of Radiology of the Fitzgerald Mercy  
Hospital

Due to economic considerations, many institutions unfortunately find themselves unable to purchase special viewing boxes for

operating room purposes, and since large windows are customarily an integral part of most operating rooms, the roentgenograms to be examined are usually fastened against the window pane, by means of adhesive plaster tabs, and thus illuminated by the transmitted daylight. This procedure is patently not applicable for viewing wet roentgenograms, which necessity not infrequently arises. The

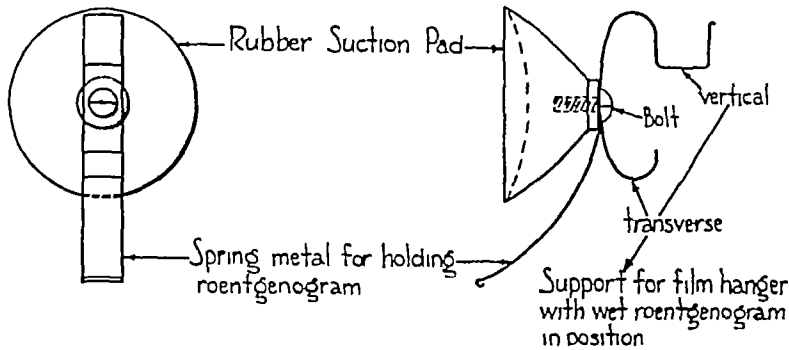


Fig 1 Front and side views of the device for holding wet and dry roentgenograms in position against the window pane for examination

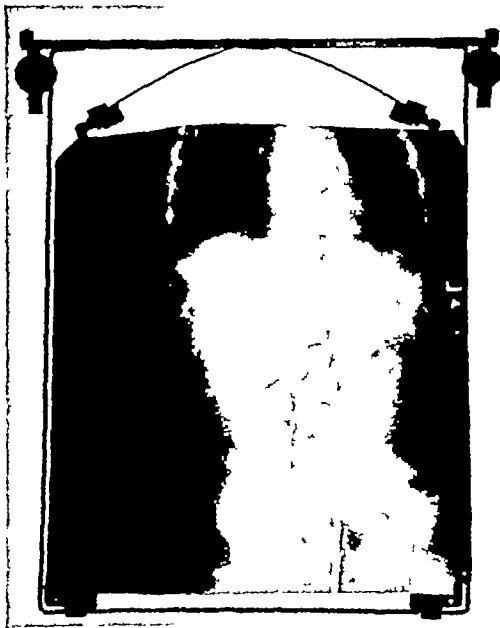


Fig 2 Showing a wet roentgenogram on its hanger, supported by the two suction pad contrivances. Both wet and dry roentgenograms can be viewed in the horizontal position also. This photograph shows the device mounted upon an operating room window.

manifold disadvantages of the current method have been successfully eliminated since adopting the inexpensive contrivance to be described below.

A coat-hanger appliance equipped with a rubber suction pad can be purchased for a small sum. This permits of secure fastening, by merely pressing the suction pad against the window pane, and contrariwise, can be readily removed or adjusted to any desired position. It is, therefore, adaptable for this special purpose, by bending the metal band of the appliance to the desired shape (Fig 1). An additional band of brass is fastened firmly in place, by means of the removable hand nut, and the device then serves the dual purpose of holding both wet and dry roentgenograms in position (Fig 2).

It is an added convenience to employ a drip-pan (positioned beneath the wet roentgenogram), to collect the water from the wet roentgenogram and film hanger. This can readily be constructed from two similar suction pads and a narrow metal tray, hooked into position (Fig 2).

A convenient calibration graph (Fig 3) is pasted upon the glass face of the prereading voltmeter. This is drafted from calibration readings. As shown, there is a milliamperage range from 5 to 100, and the various kilovolt peak factors are designated upon the ordinate and abscissa, respectively. The filament

mixed, a strip from a new  $8 \times 10$ -inch test film—exposed, as described above—is developed for 5 minutes at  $65^{\circ}$  F. After routine fixing, washing, and drying, it is labeled and used as the new standard for this quantity of developer. If, at the time the new developer is installed, the radiologist finds that he has a considerable supply of test film left, he may use this film in conjunction with the old standard for calibrating the new supply of developer. The "standard strip" is changed only at the time at which a new  $8 \times 10$ -inch test film is brought into action. This is essential because, as mentioned above, the control of a radiographic machine is not perfect enough to insure constancy of x-ray output from one test film exposure to the next.

Should the radiologist find that he is running out of test strips before the developer is ready to be renewed, a new  $8 \times 10$ -inch test film must be exposed under the aluminum step-ladder, before the last two test strips of the previous series have been used. A strip from this new test film is now developed simultaneously with one of the remaining strips of the previous film, so that both strips receive the development indicated by the previous tests. If the strip of old test film matches perfectly with the old "standard strip," the strip of the new test film can be accepted as a new "standard strip,"

for it obviously has the same density as it would have attained had it been developed for five minutes in one-day-old developer. If, on the other hand, the strip of old test film does not exactly match the old "standard strip," we still have one more undeveloped strip from the old film, with which to carry on. A new "standard strip" can now be prepared, using simultaneous development of the last strip of old film as a check upon the correctness of the degree of development.

#### SUMMARY

By using the method described, it is possible to develop all x-ray films to the same degree, from the time the developer is new until it must be thrown out. The proper time for disposal of the developer is also indicated. The method is not expensive and can easily be used by most roentgenologists.

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- (3) STONE, ROBERT S. Dept Roentgenol, Univ of Calif Med School, San Francisco, Personal Communication.



Fig 1 The aluminum step ladder placed on the cardboard film holder. There are eight steps, varying from 0 to 7 mm of aluminum

Multiplication of this appearance time by the Watkins' factor gives proper development

Chamberlain and Newell (2) have worked out and described a method of adjusting for changes in the speed of the film as well as for the weakening of the developer with use. Their method is an exact one but since the test films are made with the aid of an accurately controlled therapy machine, it is not available to many roentgenologists. Thanks to the ingenuity of Dr Robert S Stone (3), a method is here described in which the test films are exposed with a radiographic machine, such as most roentgenologists have in their laboratories.

Because radiographic apparatus is not equipped with instruments to insure constancy of output from time to time, special precautions are necessary in order that the process of calibrating the developer may be carried over from one test film to the next.

#### DIRECTIONS FOR DETERMINING THE POTENCY OF THE X-RAY DEVELOPER WITH RADIOGRAPHICALLY EXPOSED FILM

Place a fresh 8 X 10-inch film in an exposure holder (no intensifying screens) under an aluminum step ladder. The ladder we use is made of aluminum sheets 1 mm thick X 10 inches wide arranged in a staircase running from one to seven thicknesses (Fig 1). A radiographic tube is placed so that its focal spot is 60 inches above the center of the 8 X 10-inch film. Then, place 2 mm of aluminum in the filter slots of the tube stand, and expose for 14 seconds at 70 KVP, 10 milliamperes.

This film holder is opened in the dark room and about an inch is cut off one of the 8-inch ends of the film. Place this strip horizontally in one-day-old developer at 65° F for five minutes. (Absolutely fresh developer has been found somewhat variable in our experience.) After being fixed, washed, dried, and labeled, this strip is set aside as the "standard strip" with which subsequent calibration strips are to be compared (Fig 2).

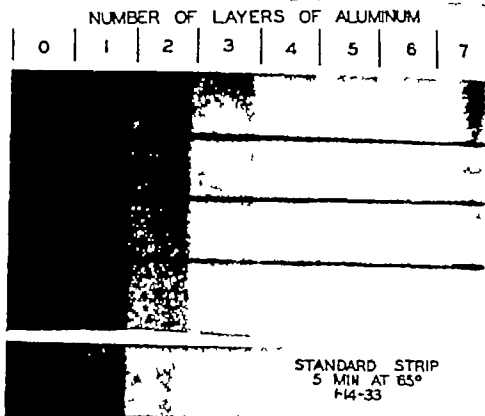


Fig 2 The finished "standard strip" is shown below. The test strips are cut, as indicated above from the undeveloped film. After development, they are compared with the standard.

From one to three days later, depending upon the size of the tank in relation to the volume of work, another strip, approximately an inch wide, is cut from the film (which in the meantime has been carefully protected from light and X-rays). This is developed for 5 minutes, placed horizontally in the developer. This strip is then compared with the "standard strip" and may be found light, due to deterioration of the developer. If it is found to be one step lighter than the "standard strip," the developing time is increased by 0.5 minute (or to 5.5 minutes), if two steps lighter than the "standard strip," development time must be increased one whole minute instead of 0.5 minute (or to 6 minutes).

From one to three days later, another strip is removed from the light-tight envelope, developed according to the number of minutes indicated by the last previous strip, and processed in the usual way. This strip is compared, as before, with the "standard strip" and if it is found to be lighter, the developing time must be further increased, 0.5 minute for each step of density-difference on the aluminum step-ladder scale. This process is repeated at intervals until the developing time thus figured reaches 8 or 9 minutes. At about this time in the life of a quantity of developer, one of three things usually happens: staining of the films, loss of contrast, indicated by inconsistent findings at the two ends of the step-ladder density scale when the calibration strip is compared with the "standard strip," or the developer is discarded, even though still working correctly, because of our desire to save time.

One day after the new developer has been

gist, who should either make the roentgenographs himself or train a technician, to make certain of the small details necessary for success. Indeed, the ability to do this work with precision is a good index of the degree of organization of the department or office. In positioning the patient the part to be demonstrated must not be obscured by bone which will blot out the detail. A knowledge of soft as well as osseous anatomy, together with a little ingenuity, will be necessary.

In determining the proper penetration to be used it is convenient to divide an extremity into three zones, as follows: Zone 1, skin and subcutaneous structures, Zone 2, muscles and periosteum, Zone 3, solid osseous structures. Each of these zones demands a different penetration. For instance, if it is desired to examine a subcutaneous hematoma, less penetration is required than for muscular detail. In the case of an individual in whom there is considerable difference in size of muscle mass, more penetration is required for the upper portion than the lower, if detail in Zone 2 is wanted. Until facility in judging exposure is acquired trial exposures over a small area are advisable.

No filter is used in non-Potter-Bucky diaphragm work. Thus, together with the high milliamperes-second ratio, increases the liability to a dermatitis. The factor of safety, however, is sufficient if due care is exercised.

A word as to the viewing of the processed radiograph. For the best results the film should be studied under an illumination of varying intensity as well as color, that is, by a yellow and then by a blue light. If this is done, the utmost can be obtained from the film.

*Conclusions*—Soft-tissue roentgenography greatly enlarges the diagnostic scope of the roentgenologist and will well repay him for the slight extra effort required.

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## COMMUNICATIONS

### INDIANA ROENTGEN SOCIETY

The seventh annual meeting of the Indiana Roentgen Society was held in Indianapolis on Feb. 22, 1934, upon which occasion John T.

Murphy, M.D., of Toledo, Ohio, addressed the Society.

The following officers were elected: *President-elect*, D. C. McClelland, M.D., of Lafayette, *Vice-president*, Ross Tracy, M.D., of Anderson, and *Secretary-Treasurer*, James N. Collins, M.D., of Indianapolis.

### MINNESOTA RADIOLOGICAL SOCIETY

The Minnesota Radiological Society held its winter meeting at the University Hospital, Minneapolis, on March 10, 1934. The following program was presented:

1. Roentgenologic Studies of Multiple Births, Leo G. Rigler, M.D.

2. The Incidence of Paraesophageal Hernia in Pregnant Women, John B. Eneboe, M.D.

Discussed by Walter H. Ude, M.D.

3. Radiation Effects on Tissue Cultures of Lymph Nodes, Joseph T. King, M.D., and K. W. Stenstrom, Ph.D.

4. The Ventriculogram in a Case of Tuberosclerosis, N. J. Berkwitz, M.D., and Leo G. Rigler, M.D.

5. Benign Strictures of the Stomach, Jacob Sagel, M.D.

6. Observations on the Radiation Therapy of Carcinoma of the Breast, K. W. Stenstrom, Ph.D.

Discussed by E. T. Leddy, M.D.

7. Histologic Studies of Human Liver after Injection of Thorium Dioxide Sol, Leo G. Rigler, M.D., and Rudolph Koucky, M.D.

8. The Epiphysis of the Tuberosity of the Fifth Metatarsal, John B. Eneboe, M.D.

Discussed by John D. Camp, M.D.

9. Roentgen Observations on Acute Amebic Colitis, Kano Ikeda, M.D.

10. Roentgen Observations on Early Tuberculosis in Young Adults, Leo G. Rigler, M.D.

Discussed by M. B. Hanson, M.D.

11. Case Reports

(a) Spontaneous Gastro-enterostomy, C. N. Borman, M.D.

(b) Lympho-epithelioma, C. O. Hansen, M.D.

(c) Trichobezoar, Oscar Lipschultz, M.D.

(d) Osteomyelitis of the Patella, Jacob Sagel, M.D.

(e) Gall-bladder Obstruction of the Small Intestine, C. N. Borman, M.D.

# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## SCOPE AND TECHNIC OF SOFT-TISSUE ROENTGENOGRAPHY<sup>1</sup>

The systematic investigation of soft tissue by radiographic methods has been attempted spasmodically since the days of pioneers. Technical difficulties, however, have been such that, with a few exceptions, the method has not become a general routine. That soft tissue roentgenography has advanced the diagnostic scope of the roentgenologist there can be no doubt. Moreover, the attention to technical details necessary for this work will result in films of improved quality even when employing the usual technics.

Let us consider briefly the practical value of soft-tissue roentgenography. We demand the same detail in the soft tissues as is necessary in the study of bones, the usual conception of mere outlines of various muscle groups, for instance, will not suffice. It is possible to visualize the normal arteries and veins, particularly at the flexures, the earliest calcification in their walls becomes visible. It is possible to delineate varicose veins. This is particularly significant as regards the deep-seated ones to determine whether or not injection therapy should be used.

Non-osseous tumors form an interesting group of cases. Often valuable information can be obtained as to extent, location, or presence of invasive properties. Muscle structure is well shown. This affords a fine opportunity to study soft anatomy, especially in relation to the bone. Calcification in muscles and rupture, if in a favorable location, can be diagnosed. While of necessity the dense bone detail is unsatisfactory, very early periosteal changes, malignant or inflammatory, become demonstrable, also early callus formation. Gall-bladder shadows following the administration of dye, particularly by the oral method, become denser and there is considerable improvement in the delineation of abdominal masses over the usual technic.

The basic essential principle is to use a low peak voltage and high milliamperes-second ratio. The three important limiting factors are (1)

capacity of x-ray tube, (2) thickness of the part, and (3) speed necessary to stop motion. In general, a 250 to 300 milliamperes-second ratio, keeping the kilovoltage as low as possible consistent with adequate penetration, is best. This means for the majority of work 100 ma. for three seconds, the KVP to be varied according to the thickness of part. A decrease in the time factor must of necessity mean an increase of the load on the tube. The use of a high milliamperes-second ratio improves soft-tissue detail even if the Potter-Bucky diaphragm is used.

A word as to machines. Any outfit having an honest rating of 100 ma., with autotransformer control of not more than 25 KVP steps should suffice. The finer the regulation of the machine the better will be the results. A fluctuating supply line will interfere with consistent results. Intensifying screens are used if soft-tissue detail alone is desired. If bone and soft tissues together are to be studied, film holders are employed. Single screens are preferable, although excellent work can be done with the double ones. Too high speed is not desirable as ensuing grain may detract from the diagnostic value of the radiograph. Uniformity of speed, however, is quite important. If more than one cassette is used, the two should be matched for screen speed.

A "contrasty," brilliant, clean base film, such as is now made by most of the manufacturers, gives the best results. Stale film should not be used. The presence of fog from whatever cause is absolutely ruinous to good results. The method of development is very important—solutions must be fresh and at a correct temperature to ensure freedom from fog or stain. A strict time-and-temperature system is quite unsuited to this type of radiography; it has to be by sight. A knack is required which is readily gained after a little experience. In the New York Hospital a small dark-room has been installed to take care of this type of work.

Soft-tissue technic is specialized work and requires particular interest from the roentgenologist.

<sup>1</sup>Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933.

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## LECTURESHIP IN RADIOLOGY

The Minnesota Radiological Society wishes to announce the establishment of an annual lectureship in Radiology in honor of Russell D Carman, M D This is to be known as the Russell D Carman Memorial Lecture, and

will consist of an address by a prominent radiologist at the annual meeting of the Minnesota State Medical Association before the general assembly of that body

The first in this series of lectures will be given by A B Moore, M D , of Washington, D C , at the meeting of the Minnesota State Medical Association in Duluth, Minnesota, July 16, 1934 In addition, at this meeting, Donald C Balfour, M D , of Rochester, Minnesota, will deliver an address on the life of Dr Russell D Carman

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J C HABBE, M D , of Milwaukee  
H W HEFKE, M D , of Milwaukee

DAVIS H PARDOLL, M D , of Chicago  
ERNST A POHLE, M D , Ph D , of Madison, Wis  
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cannot be influenced by irradiation should become fewer in number

H W HEFKE, M D

Roentgen Treatment of Uterine Fibroid and Uterine Hemorrhage with One Abdominal Field Arnold Püschel *Strahlentherapie*, 1933, XLVI, 346-354

Based on the analysis of 88 patients, the author recommends the use of one abdominal field  $10 \times 15$  sq cm at 40 cm FSD through 0.5 mm Cu, HVL in Cu, 0.95 mm. The surface dose may be as high as 600 r

ERNST A POHLE, M D, Ph D

Tables on the Absorption of Roentgen Rays H Küstner and Friedrich Voges *Strahlentherapie*, 1933, XLVI, 585-600

This series of tables facilitates greatly the calculation of the absorption coefficients and the coefficient of weakening of roentgen rays

ERNST A POHLE, M D, Ph D

### THE EYE (THERAPY)

X ray Therapy in Tuberculous Diseases of the Eye Wolfgang Hoffmann *Strahlentherapie*, December, 1933 XLVIII, 790-796

The author believes that radium is superior to roentgen rays in the treatment of tuberculous diseases of the eye. All 16 cases of tuberculosis of the conjunctiva, published in the literature, were cured by radium treatment. Four were treated by gamma rays, the others by beta rays. In tuberculous diseases of the posterior eye, he used gamma radiation exclusively. The treatment was given with 30 mg of radium distributed in 15 screens filtered through 0.2 mm Pt. They were placed in a 1 mm brass case of a  $0.5 \times 0.8$  cm surface measurement. Diseases of the anterior part of the eye were treated at a distance of 1 cm, and a total of 72 mg-hr were given during a period of 3 days. For the posterior part of the eye, the distance was increased to 2 cm, the dose to 288 mg-hr, given over a period of from 4 to 6 days. Sensitive patients received half of the dose and, if necessary, the treatment was repeated after one week. The clinical results, in 159 cases treated during the last five years, were very satisfactory.

ERNST A POHLE, M D, Ph D

### GALL BLADDER (NORMAL AND PATHOLOGIC)

Dextrose as an Adjunct for Oral Cholecystography Pfeiffer *Röntgenpraxis*, April, 1933, V, 297-299

Oral cholecystography is reported as showing a rather high percentage of failures in the author's experience. A non-functioning gall bladder was found too often in persons with a normal liver and gall bladder. Even if some of the failures may be explained by the lack of co-operation of the patient, some of them must be

attributed to other causes. Factors which might be responsible for non-filling of a normal gall bladder are precipitation of the contrast material by the gastric juice, poor resorption of the dye in the small intestines, or insufficient fixation of it in the liver cells (insufficient excretion by them). The first factor has been overcome by taking the dye with fruit juices or combining it with fruit acids. The two other factors, poor absorption from the intestine and poor function of the liver cells, must be responsible for most of the failures. In the author's opinion a liver cell loaded with glycogen is better able to fixate and excrete the dye than one poor in glycogen. For that reason, 35 gm of dextrose diluted in a glass of water were given shortly after the drinking of the dye. It seems important to have the patient drink the dye slowly (from ten to fifteen minutes is about right), as rapid drinking seems to cause much more nausea and vomiting. After this technic was initiated the results immediately became much better and are now satisfactory. In the average case the gall-bladder shadow was larger and more intense.

Some Italian authors have used 40 per cent glucose solution intravenously in combination with intravenous cholecystography and have noticed a similar improvement in their results.

H W HEFKE, M D

### GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Lymphatic Hyperplasia of the Gastric Mucosa in Lymphatic Leukemia M Lüdén *Röntgenpraxis*, November, 1933, V, 816-819

A case of lymphatic leukemia, with marked lymphatic hyperplasia of the gastric mucosa, is described. Roentgen examination of the stomach showed irregular, broken contours of the greater curvature. This appearance was first explained by the pressure of enlarged glands on the stomach, but further study showed that the mucosa relief was definitely changed and irregular, a fact which indicated an involvement of the stomach itself. At autopsy, the perigastric glands were found to be much enlarged, the gastric mucosa was thickened, the folds were wide, and in some places the mucosa was one centimeter thick. Microscopic examination showed lymphatic involvement of the entire wall of the stomach.

H W HEFKE, M D

Chronic Cicatrizing Enteritis Regional Ileitis (Crohn) A New Surgical Entity Franklin I Harris, Glenn H Bell, and Harold Brunn *Surg, Gynec and Obst*, November, 1933, LVII, 637-645

The authors suggest the term "chronic cicatrizing enteritis" for that condition of the intestinal tract previously referred to by Crohn, Ginzburg, and Oppenheimer as "regional ileitis." Regional ileitis was defined by these writers as "a disease of the terminal ileum, affecting young adults and characterized by a subacute or chronic necrotizing and cicatrizing in-

## CONTRAST MEDIA

The Patency of Biliary Ducts Determined by Radiopaque Oil Injected through a T-tube Previously Placed in the Common Bile Duct for the Purpose of Prolonged Drainage E Starr Judd and J Roberts Phillips Surg, Gynec and Obst, November, 1933, LVII, 668-671

The authors discuss the study of the biliary tract by means of the x ray during the injection of lipiodol through the T-tube employed for drainage of the common bile duct. They also report a series of four cases illustrating the value of this method.

Following the suggestion of Ginsburg and Benjamin, Gabriel injected lipiodol through the T-tube that had been placed in the common bile duct for drainage. It is possible by this method to prove definitely the patency of the ducts while the T tube is still in position. In some cases the medium reaches the smaller biliary passages and thus affords an opportunity to study these structures.

The authors select, for this procedure, only ambulatory patients who have not recently had chills or fever. The lipiodol is injected while the patient is under the fluoroscopic screen, the passage of the medium through the biliary tract being noted. After the fluoroscopic examination more lipiodol is injected through the T tube and a plain film of the abdomen is made. Although the authors have employed in some cases as much as from 15 to 20 c c of the oil, no ill effects were noted in their series of 40 cases.

J N ANÉ, M D

## DOSAGE

Comparison of the Doses Applied with the Protracted Fractional Dose Method and the Single Dose Method H Wintz Strahlentherapie November, 1933, XLVIII, 535-551

In order to compare the doses applied with the protracted fractional dose method and the single dose method, Coutard's technic was used in treating carcinoma of the cervix. The doses were calculated and checked by measurements on the phantom and on the patients. The ratios of the doses given with the single dose method and Coutard's method were as follows: For the skin, 1/2, for the carcinoma, 1/24, for the intestines, 1/22, and for the connective tissues, 1/14. The author states that the doses effective in the tumor are so high that its destruction can be explained by that fact. He does not believe that the good results obtained with the Coutard method are due to an increased radiosensitivity because of the distribution of the dose. He still favors the single dose method.

ERNST A POHLE, M D Ph D

Clinical Experience with the Protracted Fractional Dose Method in Inoperable and Recurrent Malignant Tumors of the Genital Organs and in Cancer of the Breast Paul Schumacher Strahlentherapie, 1933 XLVII, 338-343

The following technic is used: 210 K V, 2 mm Cu, half value layer in Cu 2.1 mm, 25 ma, 50-80 cm FSD, 10 x 15 and 20 x 20 cm field. The surface dose given amounts to 200 r. The total doses effective in the tumor vary between 2,000 and 3,000 r. In the beginning of the treatment the author finds little reaction. Later on, there is definite loss of weight, the leukocytes drop to 3,000 and less, at which point the treatment should be interrupted. Erythema appears after from 1,600 to 1,800 r. No late injuries have been observed up to a period of two years following the treatment. Severe late acute reactions may occur occasionally in the skin and also in the intestines.

Eight inoperable and recurrent carcinomas of the uterus were treated. Of these, three responded well, three others did not respond, and two grew worse during the treatment. Two cases with small recurrences in the parametrium disappeared following application of 2,100 and 2,300 r respectively. Three other cases with involvement of the entire small pelvis did not respond. The remaining five were patients who had received radium and single high doses of x rays. They did not respond.

Better results were obtained in 12 cases of inoperable carcinoma of the ovaries. The entire abdomen received doses of from 2,300 to 2,700 r during a period of from 7 to 10 weeks. The tumors begin to regress, usually during the third treatment week.

The same method was also used in 10 cases with recurrent carcinoma of the breast. Some of these responded well but the time of observation is still too short to permit one to draw definite conclusions. Sarcoma in the pelvis does not seem to respond at all, according to the author's experience.

In conclusion, he urges great caution in the application of this method because too high doses in too short a time may lead to disastrous results.

ERNST A POHLE, M D, Ph D

The Slow Course of Lymphogranulomatosis after Roentgentherapy M Goldstein and S S Zuckermann Röntgenpraxis, June 1933, V, 410-413

Two cases of lymphogranulomatosis (Hodgkin's disease) of unusually long duration of life are reported. One case became symptom-free for seven years after roentgen treatment, given in fractionated doses. The patient died soon after an acute recurrence. In another case the disease was kept under control for ten years and the patient's condition at the time of the last examination was satisfactory. Successful roentgentherapy may achieve complete disappearance of the granulomatous nodes.

The fractionated method seems the more advisable with one-fourth to one-third of an SED as the single dose and from 100 to 150 per cent altogether over each field. Results often depend on the stage of the disease and are naturally better in its early stages. Roentgen rays act selectively on the nodes and, with the right judgment and correct treatment, cases which

New Constructions in Grenz-ray Technik Heinz Berger *Strahlentherapie*, January, 1934, XLIX, 141-149

The author describes several new Grenz-ray tubes and types of apparatus on which this tube can be operated

ERNST A. POHLE, M D, Ph D

First Experience with Air Cooling in Grenz-ray Apparatus W Gertz *Strahlentherapie*, 1933, XLVI, 775-779

The author reports briefly his experience with air-cooled Grenz-ray tubes and discusses the cost of operation

ERNST A. POHLE, M D, Ph D

Spectrographic Studies on Different Types of Grenz-ray Tubes O Gfrörer and Heinz Berger *Strahlentherapie*, November, 1933, XLVIII, 570-577

Spectral studies on three makes of Grenz-ray tubes lead the authors to the conclusion that the half value layer in aluminum is not an accurate factor to express quality. The exact determination of the tube potential is more reliable

ERNST A. POHLE, M D, Ph D

## HEART AND VASCULAR SYSTEM

The Roentgen Findings in the Case of a Large Aneurysm of the Apex of the Heart E E Bauke *Röntgenpraxis*, June, 1933, V, 444-448

Myomalacias which lead to circumscribed bulging of the heart silhouette may be demonstrated roentgenologically. If this aneurysm-like bulging is present on the anterior or posterior aspect of the heart, a correct roentgen diagnosis may be possible only when it is large. Comparatively few cases of this kind have been described in the literature. In the author's case, a man 55 years of age with a typical history of angina pectoris and infarction of the heart muscle, a roentgenologic examination showed a round, well circumscribed bulging at the apex of the left ventricle, the size of a small apple, which pulsated with the left ventricle. An electrocardiogram showed changes typical of coronary disease and infarct. At autopsy the roentgenologic diagnosis was confirmed

H W HEFKE, M D

## RADIATION EFFECTS

Changes in Membranes under X-ray Exposure Josef Grauer *Strahlentherapie*, January, 1934, XLIX, 118-131

Saxe (*Strahlentherapie* 1931 XL 125) reported the results of his experiments regarding the effect of roentgen rays on membranes. He observed a definite change in permeability depending upon the dose. The author undertook a series of control experiments, but could not confirm Saxe's findings

ERNST A. POHLI, M D, Ph D

The Influence of Radium and Roentgen Rays, Ultra-violet Light, and Heat on the Cell Division in Warm-blooded Animals Jeno Juul and Tage Kemp *Strahlentherapie*, November, 1933, XLVIII, 457-499

Radium and roentgen exposure of tissue cultures of chicken fibroblasts produce a marked decrease of the number of mitoses during the first hour. Following a certain interval, the number of mitoses increases again. Gamma rays and x-rays produce identical results. There is no latent time. Similar changes can be observed after the tissue cultures are exposed to ultra-violet rays emitted by a quartz mercury vapor lamp. A marked drop in the number of mitoses is also observed, if the temperature of the tissue cultures has been increased from 47 to 50 degrees centigrade. An analysis of the experimental results lead the authors to the conclusion that irradiation chiefly attacks the chromatin of the nucleus, while the effect of the higher temperature is due to changes in the protoplasm

ERNST A. POHLE, M D, Ph D

The Effect of Alpha Rays on Tissue Cultures H C Andersen and M Fischer *Strahlentherapie*, November, 1933, XLVIII, 500-507

Tissue cultures of fibroblasts were exposed to alpha rays. The inhibition of growth increased with increasing dose. There was a definite latent time. Even the smallest doses did not produce a stimulating effect

ERNST A. POHLE, M D, Ph D

Radiobiology of Tissue Cultures Hildegard Vollmar and B Rajewsky *Strahlentherapie*, November, 1933, XLVIII, 508-518

The authors point out a number of errors which might creep into the results of experimental work with tissue cultures. If a culture is, for instance, slightly heated, an inhibition of growth may result, and suggest an increased radiosensitivity. The relative size of the piece of tissue and the "hanging drop" also influence the degree of radiosensitivity. The threshold values for injurious doses of ultra-violet light vary greatly for different types of tissue cultures

ERNST A. POHLE, M D, Ph D

## RADIATION INJURIES

Post-operative Treatment of Roentgen Carcinoma Karl Gütig *Strahlentherapie*, 1933, XLVII, 390-392

A roentgen carcinoma was removed from the hand of an x-ray technician. The wound healing except for a spot the size of half a dollar, upon which all known methods failed. The author then tried a 10 per cent boric acid adrenalin ointment which led to prompt healing of the defect in a few days. He suggests, therefore, that this ointment be given a trial in similar cases

ERNST A. POHLE, M D, Ph D

inflammation of all the coats of the ileum which frequently leads to stenosis of the lumen, and is often associated with fistula formation and a tumor mass in the right lower quadrant." In the authors' experience, this condition may affect the jejunum as well as the terminal ileum, and they report such a case.

The pathology in the earlier stages is confined to the mucosa of the small bowel, most frequently the ileum. This consists of small ulcerated areas on the mesenteric border of the small intestine. The submucosa and, to a lesser extent, the muscularis, are considerably thickened as a result of hyperplastic and exudative changes. This produces varying degrees of stenosis, and since the intestine, proximal to the involved segment, becomes dilated there may be alternating areas of constriction and dilatation. At a later stage, the exudative reaction is replaced by a marked fibrosis which extends into the mesentery of the involved segment of bowel. In the terminal ileum, the most intensive inflammatory reaction occurs in the region of the ileocecal valve. As a result of the pathologic changes, Bauhin's valve may be converted into a rigid diaphragm with a small opening. The ileocecal stenosis, and the hyperplastic terminal ileum, correspond to the mass often found in the lower right quadrant.

Crohn and his associates recognize four types of this disease: (1) Acute, with signs of intra-abdominal inflammation, (2) symptoms of ulcerative colitis, (3) stenosis, with symptoms of intestinal obstruction, (4) fistulous stage.

It is almost impossible to distinguish acute appendicitis from those cases with signs of acute intra-abdominal inflammation. Pain and tenderness in the right lower quadrant, fever, leukocytosis, and a mass in the right lower quadrant may be present.

In the second type, there is a history of diarrhea associated with peri-umbilical and lower abdominal pain. Pus, mucus, and visible blood may be present in the stools. Constant fever, loss of weight, and secondary anemia are noted during the course of the disease, which may last as long as a year. In the majority of cases, the patient passes gradually into the stenotic phase of the disease.

The stenotic type, which is more frequent, is marked by symptoms of partial obstruction. Violent cramps, vomiting, visible peristalsis, distention, and a palpable mass may be noted. It is possible for the stenotic phase to be the first manifestation of the disease.

Fistula formation marks the fourth or fistulous stage. Practically diagnostic of the disease is a fistula in the abdominal wall, persisting and appearing after operation for a supposed acute appendicitis and the removal of an innocent appendix. These fistulae usually occur months after the operation and after the original incision has healed. The first sign is usually an abscess on the abdominal wall which, on being opened, leads to the intestines.

Radiologic examination in these cases may show delay in the small intestines early in the disease. Later in the stenotic phase definite evidence of obstruction

with dilatation of small bowel loops, may be noted. While the symptoms may suggest ulcerative colitis, a barium enema will not reveal the pathology which will be disclosed by serial roentgenologic examination.

The treatment of this condition is surgical, medical treatment being only supportive and symptomatic.

J N ANÉ, M D

A Further Contribution to the Roentgenologic Diagnosis of the Small Intestines. The Flexura Ultima. Th Rövekamp Röntgenpraxis, June, 1933, V 413-422.

Anatomical variations of the last portion of the ileum are numerous. Fixation of the last loop to the cecum (by adhesions or congenital bands) can be diagnosed only when this part of the small intestines is found at repeated examinations to be fixed. A change in tone may lead to abnormal situations, kinks, elongation, narrowing, and the like. In the case of a cecum mobile, one may see the last small intestinal loop in many different positions. In most cases there are no symptoms, but occasionally one must attribute the symptoms of a patient to this anomaly. Pathologic changes in the appendix may cause fixation of the last loop of the ileum by adhesions. Tuberculosis or dysentery are other causes for immobility of this portion of the small intestine, even without fixation of the cecum. Of course, abdominal tumors will displace the last flexure. It has not been possible to diagnose tuberculosis of the small intestines by examining roentgenologically the mucosa-relief. Tuberculosis of the cecum is usually associated with it and can be demonstrated rather easily.

H W HEFKE, M D

## GRENZ RAYS

Seven Years' Experience with Grenz-ray Therapy of Lupus. G Schulte Strahlentherapie, December, 1933, XLVIII, 690-697.

The author relates his experience with Grenz-ray therapy of lupus vulgaris. He recommends 2,000 to 2,500 r (10 KV, 10 ma, 0.5 cm FSD) to be repeated after from 8 to 14 days. It is necessary to produce marked reactions. He has seen no untoward results after these high doses. A combination with ultra violet radiation is recommended.

ERAST A POHLE, M D, Ph D

Grenz Rays in Tuberculosis of the Skin. B Speth off Strahlentherapie, December, 1933, XLVIII, 685-689.

The author has obtained good results with Grenz rays in large doses (4,600 r, 9 KV, 2.5 cm FSD, HVL in Al, 0.015 mm). He stresses the importance of using "soft" radiation. It is possible to apply as much as 22,000 r over small areas. A combination with infra-red rays proved very effective.

ERAST A POHLE M D Ph D

neck. The pathologic processes noted consisted of focal cerebral defects of varying extent

Considerable variance may, likewise, be exhibited in the clinical picture of these cases. The convulsions and hemiplegia may occur immediately or some time after the trauma or acute infectious onset. During the course, the seizure may change in character. Considerable uniformity occurs in the early age at which the disease begins. The authors' cases dated back either to birth, or to the first 15 months of life, with the exception of one patient in whose case the symptoms were first noted at six years of age. When it is remembered that the infant's skull is relatively soft and malleable, the uniform changes occurring in the skull in this condition may be accounted for. If the bones are soft enough, an actual flattening or even depression of the vault on the side of the lesion may occur. If, on the other hand, the vault is rigid enough to withstand the unequal pressure from the two sides, the osteoblasts of the inner table are unequally stimulated or the normal absorption of the inner table fails to take place and a thickening of the bones of the skull over the defect results. In the region of the sinuses, the process of space elimination occurs by an expansion of these air spaces and a pneumatization of the bones.

The roentgenologic examination revealed a thickening of the cranial vault on the same side as the cerebral lesion, an over-development of the frontal and ethmoid sinuses, and of the air cells of the petrous pyramid of the temporal bone. Encephalography shows enlargement of the lateral ventricle on the affected side, and sometimes of the third ventricle, these structures being displaced toward the side of the cranial lesion. This condition may be distinguished from tumor by the absence of signs of increased intracranial pressure, and by the presence of changes in the vault and sinuses in cerebral hemiatrophy.

J N ANÉ, M D

Cysticercosis in Twin Brothers, Aged 13 Years, with a Radiological Study of the Calcified Cysticercus in 12 Cases. W K Morrison. *British Med Jour*, Jan 6, 1934, No 3809, 13-14.

The author reports the case of a schoolboy, aged 13 years, who was referred for an x-ray examination of the skull, following symptoms which were epileptiform in character. The radiographic examination revealed a normal skull with nine small circular opacities similar to those caused by calcified cysticerci. The limbs of this patient were next examined by means of the x-ray and 23 calcified cysticerci of various shapes were discovered. This boy had a history of six mild fits the first of which occurred at the age of 18 months. X-ray examination of the twin brother of the patient, although this boy had never had fits, showed a calcification in the region of the right side of the neck which resembled cysticercus. It was also of interest to note that the patient and his family had spent two and one-half years in India.

In a series of 12 cases of cysticercosis, calcified cysticerci were found in the brain in only two patients. The

amount of calcium deposit, and the time taken to calcify, depend on several factors not well understood at this time. The opaque shadows seen in these cases represent the following: The calcifying or calcified scolex, the true bladder in which development occurs, the remains of the fluid contents of the true bladder, the outer cyst wall provided by the tissues of the host, and the remains of the fluid contents of this outer cyst. The shapes noted resulted from pressure by neighboring structures.

J N ANÉ, M D

## THE SPINE

Our Experience with Tuberculosis of the Spine. V Schiller and W Altschul. *Röntgenpraxis*, July, 1933, V, 481-487.

Tuberculosis of the spine represents the largest percentage of cases of tuberculosis of the bones. The upper and lower portions of the spine are only rarely attacked, toward the middle of the spine this disease is found much more often, while the lower fourth portion of the dorsal spine is attacked most often (29 in 85 cases). The high percentage of tuberculosis in this area may be explained by the fact that it is exposed to trauma more than any other part of the spine.

The different types of disease may be grouped as follows:

1 Slight changes, representing cloudiness of the bone structure, slight irregularities of the contour, and difference in height of the bodies (3 cases).

2 More marked erosions on the joint surfaces of the vertebrae, usually combined with disease of the corresponding surface of the next vertebra (4 cases).

3 Small defects on the anterior edges of the vertebrae, visible on lateral roentgenograms (2 cases). This proves the importance of a lateral view, which should represent no technical difficulty.

4 Extensive destruction, with compression of vertebrae.

(a) Wedge shaped vertebra, the narrowest point being anterior (9 cases).

(b) Marked compression, with protruding of fragmented bone above the normal anterior boundary of the vertebra.

(c) Pushing together of two neighboring vertebrae with wedging and healing by "block formation" (14 cases).

(d) Healing by formation of bony bridges between the vertebrae (6 cases).

(e) Extreme deformities by healing in almost a right-angle (becoming less frequent). These cases (2) showed no symptoms of spinal cord changes.

Only one death occurred (the patient left the institution before the end of the treatment). The other patients were in part cured, in part so much improved that they were able to work. The treatment consists of x-ray and roentgen therapy, in combination with orthopedic and dietetic measures.

H W HFFKE, M D

Clinical Illustrations of Deep Roentgen ray and Radium Burns John Staige Davis *Am Jour Roentgenol and Rad Ther*, January, 1933, XXIX 43-78

This article is profusely illustrated with films of patients before and after operative treatment for various degrees of severe x ray reactions. The author groups these cases according to location on the head and neck, trunk, and extremities. According to present-day standards of safety, many of these cases obviously represent careless radiation therapy technique or unthinking diagnostic fluoroscopic work. It is the writer's belief that the only rational method of treatment is complete excision of the damaged tissues, with tissue-shifting to fill the defect thus made. The illustrations indicate the excellent cosmetic results which may be obtained in addition to relief of the pain and disfigurement which usually accompany the unhealed so-called "burn."

J E HANDE, M D

Abnormal Growth of Hair Following Roentgen Examination Herbert Schlathöfer *Strahlentherapie*, 1933, XLVII, 393-395

The author described the history of a man who, in 1904, when 16 years old, had an x ray film made of the cervical spine. He also was fluoroscoped seventeen or eighteen times afterwards. He developed a severe reaction which was treated by ointments. In the exposed field (posterior shoulder region) a marked pigmentation appeared followed by growth of hair. Photographs show this rather interesting phenomenon.

ERNST A. POHLE, M D, Ph D

The Problem of X-ray Injuries Following the Treatment of Tuberculosis of the Skin Karl Hoede *Strahlentherapie*, December, 1933, XLVIII, 680-684

The author studied the question of late injuries following x ray therapy of skin tuberculosis. He comes to the conclusion that, if treatment is applied properly, there will be no late injuries. The publication of such cases should not, therefore, lead to the discontinuation of roentgen therapy in tuberculosis of the skin. He has observed patients who were treated during childhood, without for many years seeing any undesirable results. There seems to be no connection between carcinoma growing in a tuberculous skin area and previous roentgen therapy.

ERNST A. POHLE, M D, Ph D

## RADIUM

A Case of Chorio-epithelioma of the Vagina Cured by Radium Felix Gal *Strahlentherapie*, 1933, XLVII, 322-325

The author reports a case of chorio-epithelioma in the vagina in a woman 37 years of age. Local radium application and x-ray deep therapy to the pelvis led to a clinical cure.

ERNST A. POHLE, M D, Ph D

Five year Results of Suprapubic Radium Implantation into Bladder Tumors Edward L. Keyes *Surg., Gynec. and Obst.*, February 1, 1934, LVIII, 233-237

The author reviews the case histories of his series of bladder tumors treated by suprapubic radium implantation and analyzes the 5-year results in this group. The mortality for the whole series was 61 per cent, and the 5-year cures, 29 per cent.

The cases had been divided previously into the following groups: Papilloma and Grade I, Grade II, Grade III, Grade IV. This classification was based on a combination of clinical and pathologic observations somewhat similar to that employed by Dr. Barringer in 1928.

The prognosis in Grade III was bad and that in Grade IV even worse. In Grade III the author obtained 23 per cent 5-year controls, and in Grade IV only one patient survived for a period of 6 years and then died of cancer.

While no attempt is made to compare radon implantation with other forms of surgical procedures, such as resection of the bladder, the use of radon has the following advantages: No ureteral re-implantation has to be done, the operative mortality is much lower, and the stay in the hospital is shorter.

Many of the patients of this series were treated with a lower dosage of radium than employed to-day by the author. The former 1 millicurie or 1.5 millicurie radons have been replaced by 2 millicurie radons.

J N ANÉ, M D

The Permeability of the Skin for Radium Emanation W. Santholzer *Strahlentherapie*, November, 1933, XLVIII, 519-534

The radio activity of the blood, following a radioactive bath, was determined in blood specimens of 40 cc each. From five tests, the author concludes that the skin is permeable for radium emanation. A theoretical explanation is offered.

ERNST A. POHLE, M D, Ph D

## THE SKULL (DIAGNOSIS)

Cerebral Hemiatrophy, with Homolateral Hypertrophy of the Skull and Sinuses. Cornelius G. Dyke, Leo M. Davidoff, and Clement B. Masson *Surg., Gynec. and Obst.*, November, 1933, LVII, 588-600

The authors report a series of nine cases, with a clinical picture of infantile hemiplegia which showed roentgenologic changes in the skull.

There is apparently no uniformity of etiology, for, of the nine patients included in this report, four showed a sudden onset post-natally with fever, convulsions, and hemiplegia, two occurred as a result of trauma received at birth, one was of pre-natal origin, in another, the symptoms began after a severe fall at the age of one year and the remaining case followed partial asphyxiation due to a tight umbilical cord around the

is given twice a week, until a total dose of 600 r has been applied. The results were so encouraging that he recommends this procedure for further trial.

ERNST A. POHLE, M.D., Ph.D.

### TUBERCULOSIS (DIAGNOSIS)

Communication between the Two Pleural Sacs, with Lungs Showing Tuberculosis Healed after Thoracoplasty. Charles R. Smith and H. S. Willis. Jour. Am. Med. Assn., Oct. 14, 1933, CI, 1224-1226.

This is a case report of a man, aged 35, in whom an attempt to induce pneumothorax on the left side induced pain on the right side and led to the discovery of an interpleural communication. Demonstrable interpleural communications in man are notably uncommon. The anatomic basis of such natural and spontaneous phenomena is not clear, however, the basis for possible rupture or mechanical break does exist in the anatomic structure of the mediastinum. Nitsch described two "weak places" in its structure, one posterior to the upper portion of the sternum at the second, third, and fourth ribs, and the second in the posterior inferior portion of the mediastinum near the level of the eighth rib. In the presence of a pneumothorax with high pressure, the possibility of a pleural tear in either of the weak places must be considered.

C. G. SUTHERLAND, M.D.

Tuberculosis of the Greater Trochanter. Henry W. Meyerding and Rudolph J. Mroz. Jour. Am. Med. Assn., Oct. 21, 1933, CI, 1308-1313.

Spalteholz described 16 bursae in the region of the hip, and other observers have described as many as 31. Most of these are not constant and are small, the most important are the gluteus maximus bursa over the greater trochanter, the iliopectineal bursa, and the ischiogluteal bursa. The iliopectineal bursa is often directly connected with the hip joint. Tuberculosis of the greater trochanter and the bursa over the trochanter start usually in adolescence and are to be distinguished from disorders of the hip joint and from neoplasms. Adequate treatment consists of radical excision of the diseased bursa and trochanter. Primary infection is usually in the trochanter and may spread by continuity to the bursa. In cases in which apparently only the bursa is involved, perfect healing followed surgical treatment. Evidence of tuberculous disease was found in 73 per cent of the authors' cases. 42 per cent in the lung and 31 per cent in other parts of the body. Roentgenograms showed involvement of the trochanter in 78 per cent.

C. G. SUTHERLAND, M.D.

Multiple Round Tuberculous Foci in the Lungs. H. Meyer Borstel. Röntgenpraxis, May 1933, V, 321-329.

Multiple coinlike, well circumscribed shadow in lung roentgenograms are generally considered as

typical for metastases. Lichmann recently described an atypical lung tuberculosis simulating metastases, the clinical picture and the course of the disease proving the disease to be a tuberculosis. The author has also seen several such cases and reports seven of them. Reproductions of films illustrate his contention that multiple round circumscribed areas of infiltration may be the roentgenologic representation of tuberculous foci. History and clinical findings are given in order to prove the tuberculous nature of these structures. In two cases these round areas disappeared completely, just as a primary intracavitary tuberculous infiltrate would do. One case was especially interesting, because it showed carcinomatous metastases as well as multiple round tuberculous infiltrations in the lung on roentgenograms as well as at autopsy. The last roentgenogram showed multiple, very small shadows in the right upper and middle lobes and six well circumscribed round shadows, the size of a cherry, in the same area, also three similar shadows in the left lung. While the entire lung pathology was first diagnosed as tuberculosis, this opinion was changed and all lung pathology was attributed to carcinomatous metastases, when metastases were found in the skeleton. Postmortem examination, however, showed (corresponding with the round shadows on the roentgenogram) old cirrhotic tuberculous nodes in the lung, only the fine mottling being due to carcinomatous metastases.

A differential diagnosis between metastatic and tuberculous round infiltrations is often impossible without the history and clinical findings. From the number of these shadows, their shape, size, and density, it is impossible to draw any conclusion. Occasionally the round tuberculous foci may show a less defined border and small irregularities of the edges.

H. W. HIRKE, M.D.

### TUBERCULOSIS (THERAPY)

Advanced Bladder and Urethral Tuberculosis. Treatment by Ureteral Transplantation following Preliminary Colostomy. Reed M. Nisbitt. Am. Jour. Surg., December, 1933, XXII, 547-549.

Progression of bladder lesions following nephrectomy for unilateral renal tuberculosis offers a serious obstacle to recovery. When complicated by tuberculous stricture of the urethra, this condition is likely to terminate fatally. Putting the bladder at complete rest by diversion of the urinary stream constitutes the soundest policy of treatment. The most satisfactory methods for accomplishing this are ureterectomy or ureteroenterostomy. Of the two, the latter is the more desirable procedure but carries the distinct hazard of infection in these patients, who are, at best, poor operative risks and tolerate infections poorly. Colostomy as a preliminary measure before ureteral transplantation is proposed as a method for eliminating this hazard of infection. A case successfully treated by this method is presented.

DAVID H. PARSONS, M.D.



A Case of Nucleus Pulposus Prolapses Schwede  
Röntgenpraxis, July, 1933, V, 515-517

Since Schmorl's publication in this field so many case reports and publications have appeared that Schmorl's bodies, or prolapse of the nucleus pulposus of the intervertebral discs are now generally known and recognized by almost every roentgenologist. According to Schmorl, the possibility exists that occasionally such a prolapse may occur after injury, usually, however, in his opinion a continuous chronic strain must be held responsible in the case of young persons (sport, motor-cycling, etc.) In the case reported by the author a nuclear prolapse could be seen in the ninth dorsal vertebra, which also showed evidence of an old healed compression fracture (probably due to an injury eight years before). There were also multiple prolapses of nuclear tissue in the lumbar vertebrae. The patient complained of having suffered backache for five years, especially after strain and exercise. According to Brandes, one is justified in considering such prolapse in the immediate neighborhood of a fractured vertebra as direct result of an injury. It seems to the author that the changes in the lumbar spine should be attributed to the same trauma. Most authors believe that these Schmorl's bodies cause no, or very slight, symptoms. However, in some cases slight back symptoms can be explained only by their occurrence.

H W HEFKE, M D

The Roentgenologic Appearance of the Vertebra Plana Calvé and its Interpretation Federsmidt  
Röntgenpraxis November, 1933, V, 801-805

Only about 20 cases of vertebra plana first described by Calvé, have been reported in the literature. The author found 2 in 50 cases of tuberculous spondylitis which he observed from 2 to 3 years. The prognosis of this disease is very favorable, and for that reason it is important to differentiate it from the very similar appearance of tuberculosis. It is impossible to make a definite diagnosis in the first stages. In a girl 4 years of age the first roentgenologic finding was a decrease in the height of the intervertebral disc between the second and third lumbar vertebrae which looked typical for a beginning tuberculous spondylitis. Five months later the third lumbar vertebra was markedly flattened and showed increase in its width, the intervertebral disc was of normal height. In tuberculosis and osteomyelitis the narrowing of the disc is permanent and irreparable. The breaking down of the vertebra takes place very rapidly in Calvé's disease. In the second of the author's cases the characteristic flattening was seen as early as 6 weeks after the beginning of the symptoms. The final deformity of a typical Calvé vertebra should be uniform flattening. Other deformities should make one hesitate about the diagnosis. In some cases the diseased vertebra regenerates to a certain extent contrary to the findings in tuberculosis. Autoptic findings about this disease have not been reported. It may best

be explained by a local malacia, comparable with the malacia in Köhler's disease.

H W HEFKE, M D

## THE THORAX

The Inferior Accessory Lobe of the Lung Leo G. Rigler and Lester G. Erickson. Am Jour Roentgenol and Rad Ther, March, 1933, XXIX, 384-392.

While autopsy figures indicate the occurrence of a partly or completely formed inferior accessory lobe in either the right or left lung in as high as 45 per cent of cases, Rigler and Erickson were able to demonstrate the same anatomic variation roentgenographically in 82 per cent of unselected chest films. Even so this indicates a much greater frequency of occurrence and demonstration than the much discussed azygos lobe which occurs with a frequency of only about 1 per cent of unselected cases. Cases have been clinically observed with lower lung pneumonias which involved either the accessory lobe only or the lower lobe proper but not the accessory one. Demonstration of the fissure in the right lung is easier than in the left because of the position of the heart. Differentiation must be made between an infiltration of the accessory lower lobe from encapsulated mediastinal pleural effusion, from atelectasis of the medial portion of the lower lobe, and, less commonly, from paravertebral abscess and aneurysm of the descending aorta.

J E HABBE, M D

Multiple Round Shadows in Roentgenograms of the Lungs Frank Kellner. Röntgenpraxis, November, 1933, V, 806-809.

Multiple round shadows in lung roentgenograms are relatively rare, if not caused by metastases or echinococci. They are probably mostly due to tuberculous foci but may be caused also by other inflammatory diseases. A case is described in which multiple, fairly large, and fairly well circumscribed shadows were found in the roentgenogram of the lungs after the patient had gone through an acute lung disease. Metastases, tuberculosis, echinococci and syphilis could be excluded clinically. During the course of a few months the lungs became entirely normal. It is concluded that these round shadows represented localized areas of unresolved or slowly resolving bronchopneumonia. This case indicates that one must not think only of metastases, echinococci, and tuberculosis but also of bronchopneumonic processes, when confronted with such shadows.

H W HEFKE, M D

The Treatment of Chronic Empyema. Udo Ellersbroek. Strahlentherapie, November, 1933, XLVIII 562-569.

The author describes a case of empyema which he treated by roentgen rays. He applies two fields over the fistula, using the following technic: 200 K V, 1 mm Cu + 1 cm Al, 30 cm FSD, 60 r. This dose



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# RADIOLOGY

Roentgen Therapy of Tuberculous Glands W Baensch Strahlentherapie, December, 1933, XLVIII, 766-770

Heavily filtered roentgen rays (0.5 Zn + 3 Al) in doses of from 30 to 50 per cent E D, given three times at intervals of 8 days, are recommended by the author. According to the literature, the percentage of cure varies from 40 to 90 per cent.

ERNST A. POHLE, M.D., Ph.D.

Successful Removal of an Entire Lung for Carcinoma of the Bronchus Everts A. Graham and J. J. Singer Jour Am Med Assn, Oct 28, 1933, CI, 1371-1376

Primary carcinoma of the lung almost always arises in a bronchus. Up to the present time the prognosis has been almost uniformly bad because of the complete futility of any methods of treatment other than surgical excision. There is no record in the literature of the successful treatment by radiotherapy of a single case in which the pathologic evidence has been incontrovertible and in which a five year period without recurrence has elapsed between the treatment and the time of reporting the case. The authors report apparently the first case in which an entire lung has been successfully removed for a carcinoma.

C. G. SUTHERLAND, M.D.

The Role of the Ureter in Renal Tuberculosis Robert V. Day Am Jour Surg, December, 1933, XXII, 542-546

In dealing with this subject the author arrives at the following conclusions: Where a tuberculous lesion has advanced to the renal pelvis or collecting tubules, renal tuberculosis never completely heals, because of the handicap of hindered drainage and back pressure, due to tuberculous changes in the ureteral wall. That is to say, aside from other possible reasons, a tuberculous kidney excreting tubercle bacilli cannot recover because an incurably strictured ureter interferes with normal drainage and peristalsis. When complete healing does occur, the tuberculous process is limited

to the cortex, etc., it has never been found to extend to the pyramid or collecting tubules. Until the tuberculous process has extended to a calyx or the collecting tubules pus and tubercle bacilli of renal origin will not be found in the urine, and, therefore, up to this time renal tuberculosis may not be said to be "clinically established."

DAVIS H. PARDOLL, M.D.

## TUMORS (DIAGNOSIS)

Some Evidences of Intracranial Disease as Revealed by the Roentgen Ray Charles Wadsworth Schwartz Am Jour Roentgenol and Rad Ther, February, 1933, XXIX, 182-193

Intracranial calcifications are classified by the author as to form in three groups: punctate, linear, and amorphous.

Approximately 50 per cent of all intracranial tumors fall in the glioma group. While only about 13 per cent of these show direct evidence of their presence and location by calcification, a highly probable diagnosis is possible in about 50 to 60 per cent because of indirect signs. Such tumors often reach tremendous size without causing signs of increased pressure. Pressure signs may develop quite rapidly, especially in a child's skull and conversely may disappear rapidly with release of the pressure.

Pituitary adenomas are variously reported as occurring with a frequency of from 5 to 19 per cent. Local pressure changes are the rule, with the suprasellar cysts often showing calcification.

Temporal lobe tumors often produce asymmetrical erosion of the sella. Petrous ridge atrophy may be caused by acoustic neuromas or by metastatic disease. Osteochondromas, meningiomas usually show local increased vascularity and may show osteoporosis or marked hyperostosis, calcifications of crescentic form over the sella, with sellar destruction, constitute changes characteristic of carotid aneurysm.

The article includes many excellent illustrations.

J. E. HABBE, M.D.

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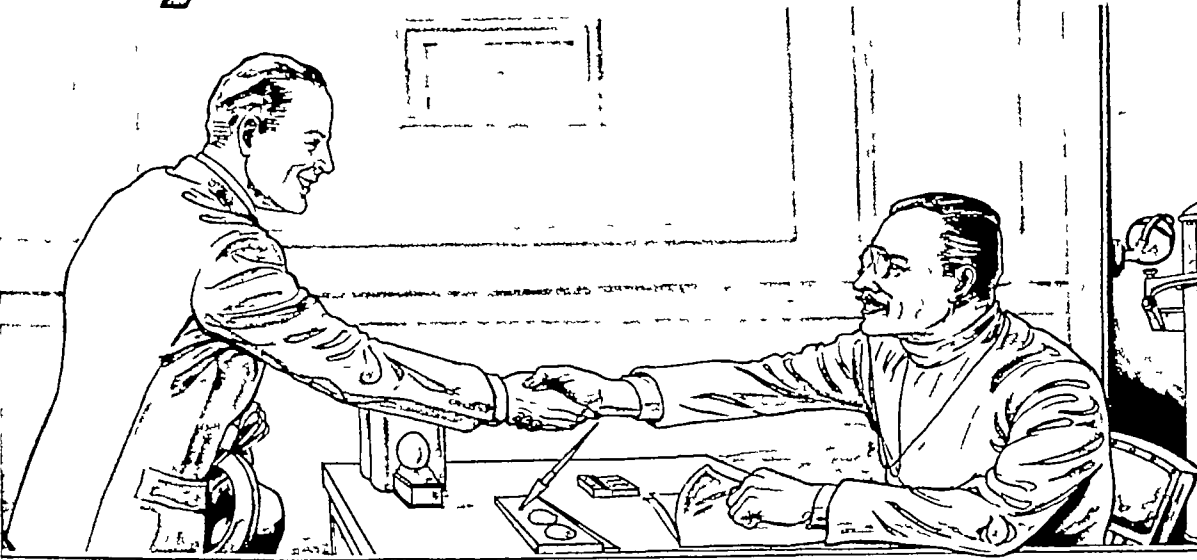
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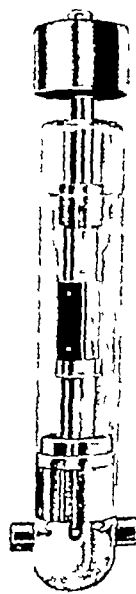
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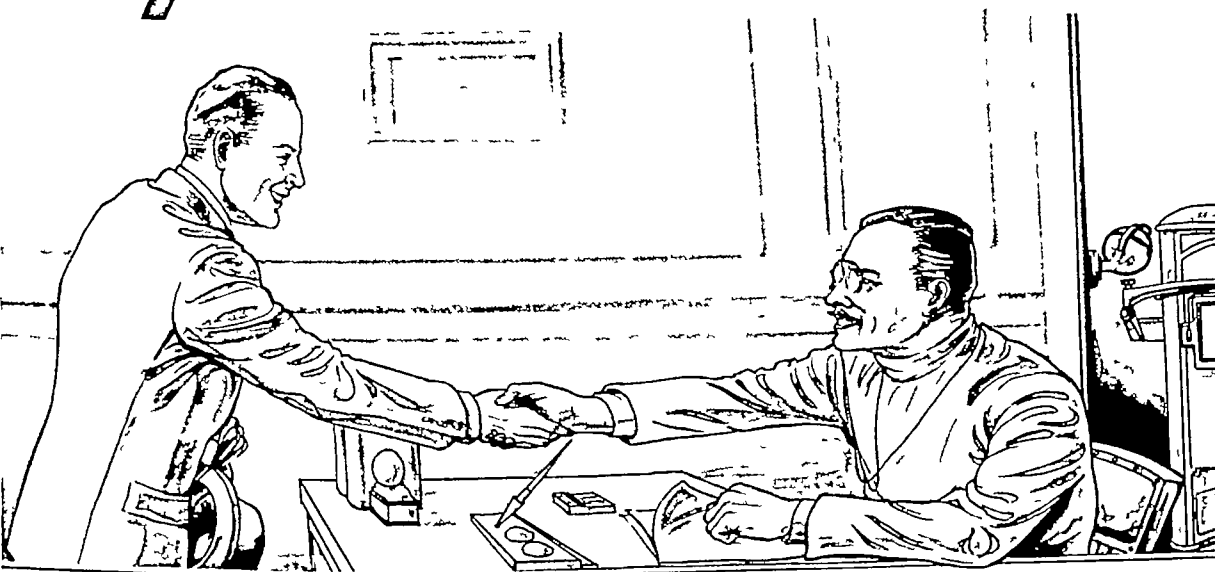


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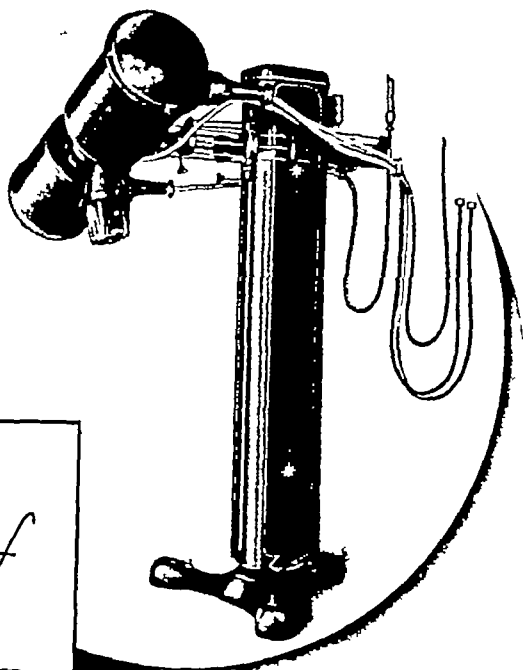


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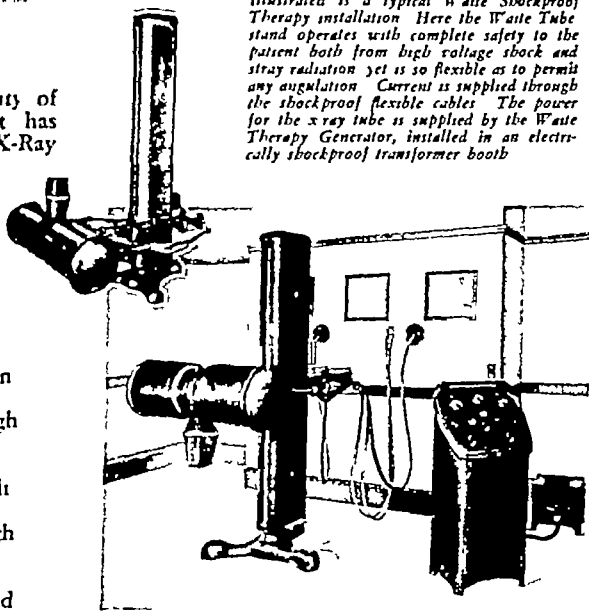
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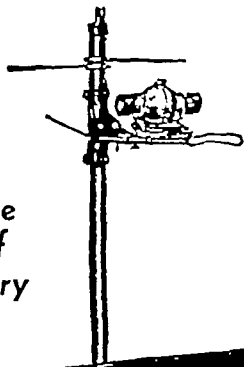
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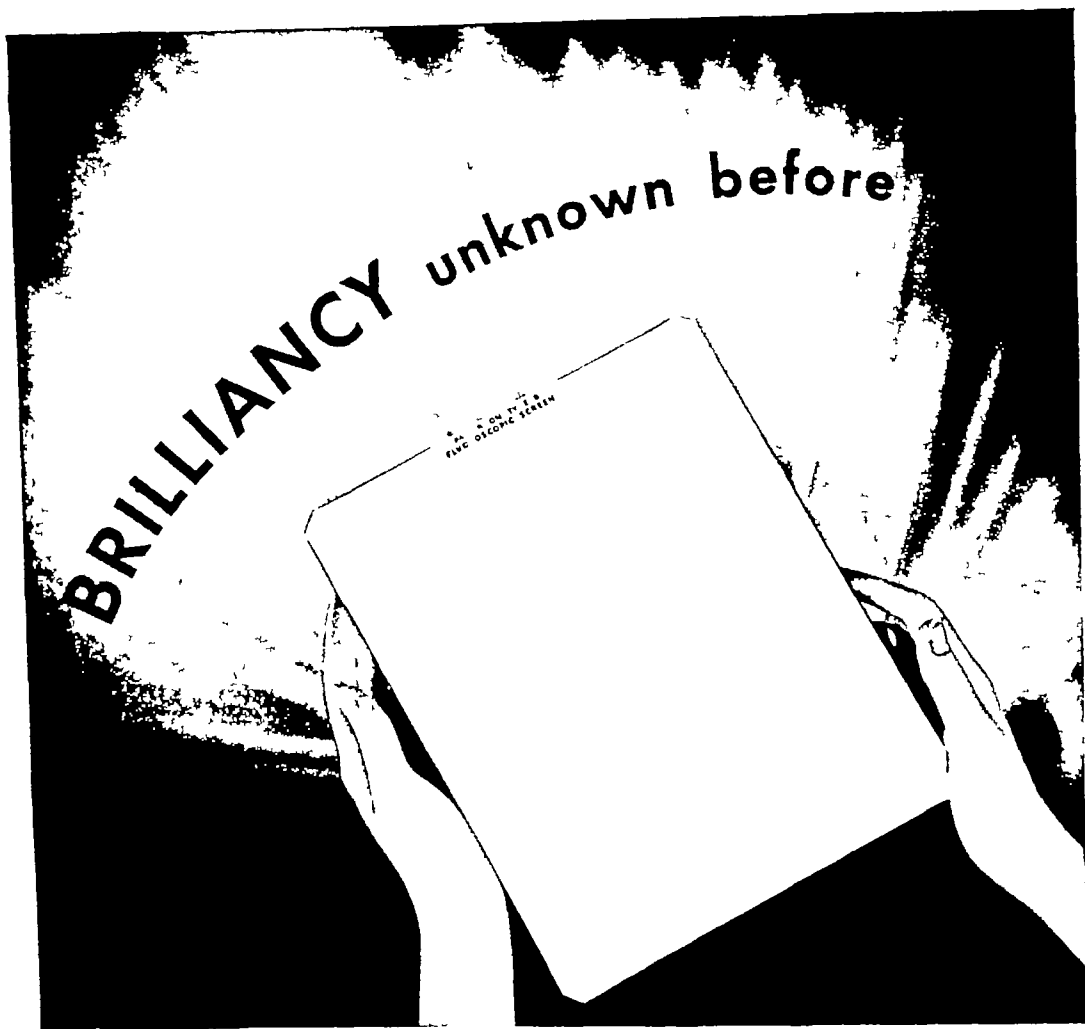
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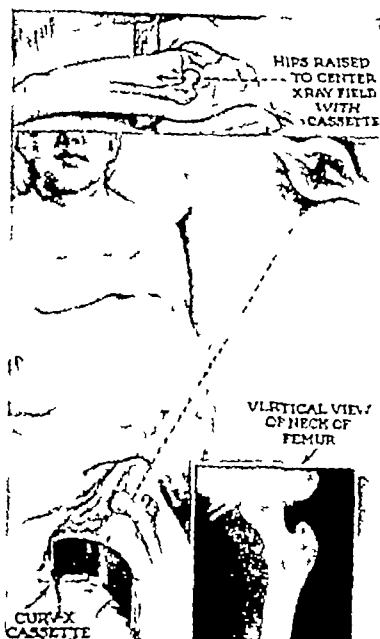


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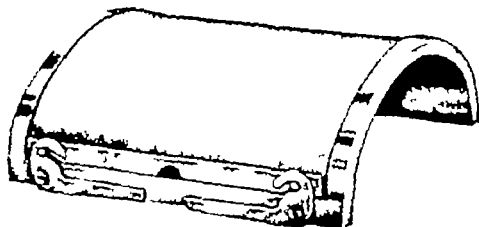


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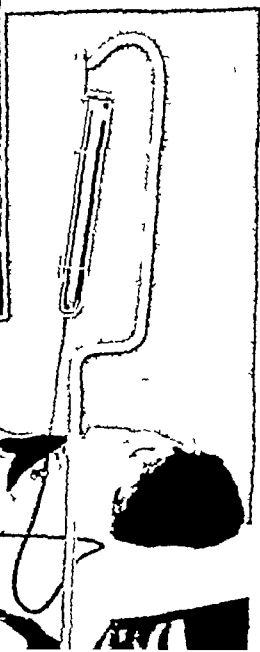
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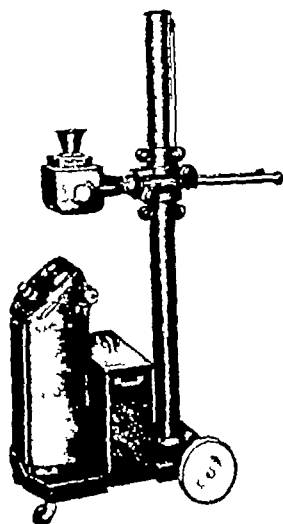
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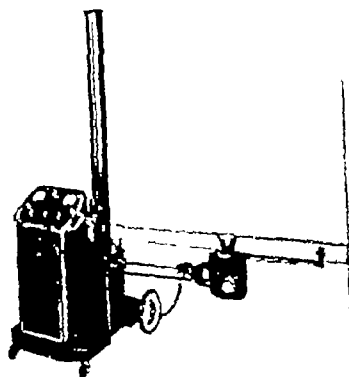
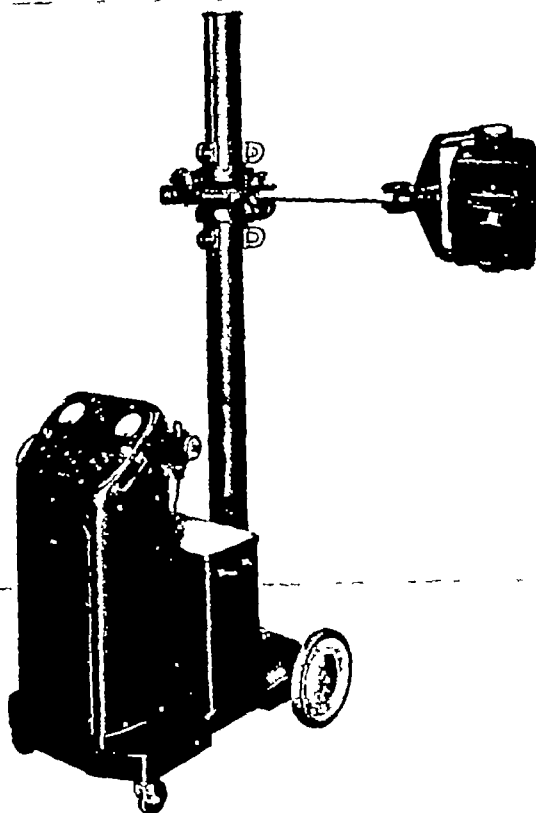
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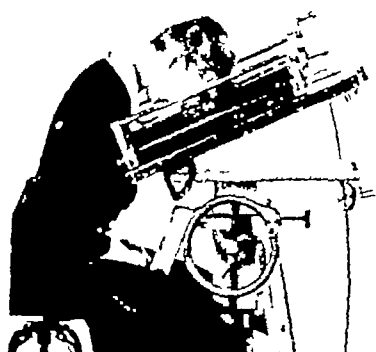
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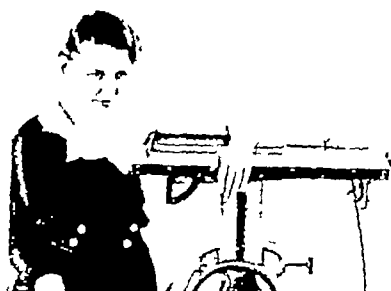
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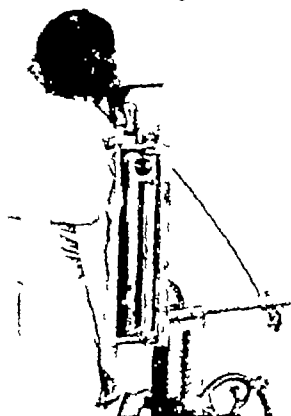
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*Posture for sinus radiography. Stand top at 23° angle.*



*The stand top set in horizontal position to radiograph elbow.*



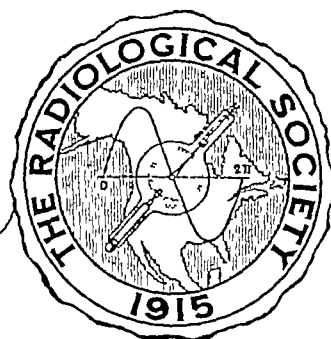
*Posture for gall-bladder or gastro-intestinal examination. Stand top vertical.*

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A MONTHLY JOURNAL DEVOTED  
TO CLINICAL RADIOLOGY AND  
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JUNE 1934

VOLUME XXII

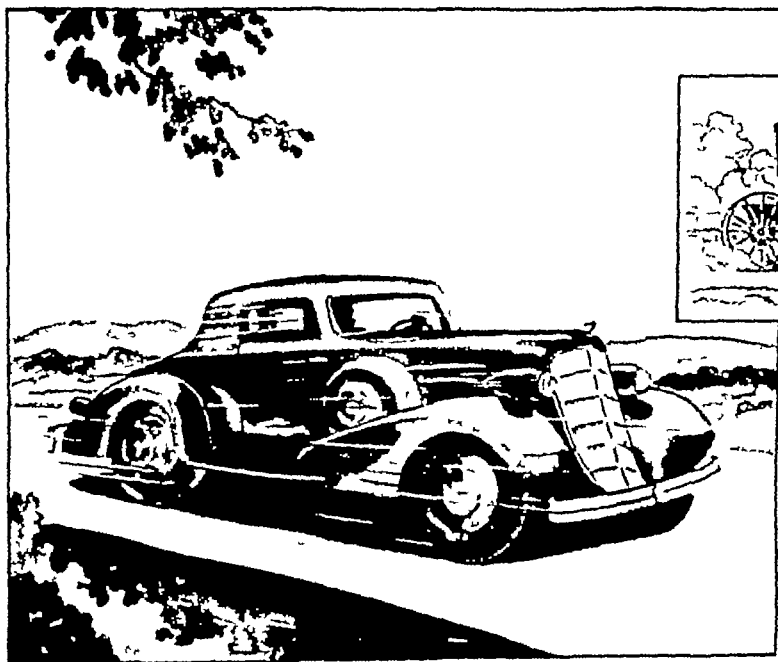
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RADIOLOGY is entered as second class matter April 23, 1934, under the Act of August 24, 1912. RADIOLOGY is printed at and distributed on the 15th of each month from 20th and Northampton Streets, Easton, Pennsylvania, is published by the Radiological Society of North America as its official Journal. Subscription rate, \$6.00 per annum. Canadian and foreign postage, \$1.00 additional. Single copies, 75c each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY or remittance for non-member subscriptions should be made payable to the Radiological Society of North America and should be addressed to the Secretary-Treasurer, Donald S. Childs, M.D., 607 Medical Arts Building, Syracuse, New York. In requesting change of address, both the old and the new address should be given.

RADIOLOGY is published by the Radiological Society of North America, under the supervision of a Publication Committee, who reserve the right to reject any material submitted for publication, including advertisements. All correspondence relating to publication of papers should be addressed to the Editor, Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, Louisiana. Original articles will be accepted only with the understanding that they are contributed solely to RADIOLOGY. Articles in a foreign language will be translated if acceptable. Manuscripts should be typewritten, double spaced, with wide margins on good paper, and the original, not a carbon copy, submitted. It is advisable that the author keep a carbon copy, as used manuscripts will not be returned. The author's full address should appear on the manuscript. Photo-

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Inquiries regarding the program of the meeting of the Society for the current year should be sent to the President.

The Editor accepts no responsibility for the opinions expressed by the contributors. We endeavor to publish the papers as submitted, reserving the right to introduce such changes as may be necessary to make the contributions conform to our editorial standards.

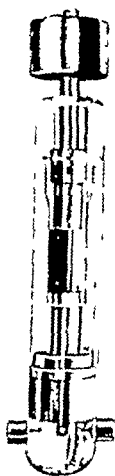
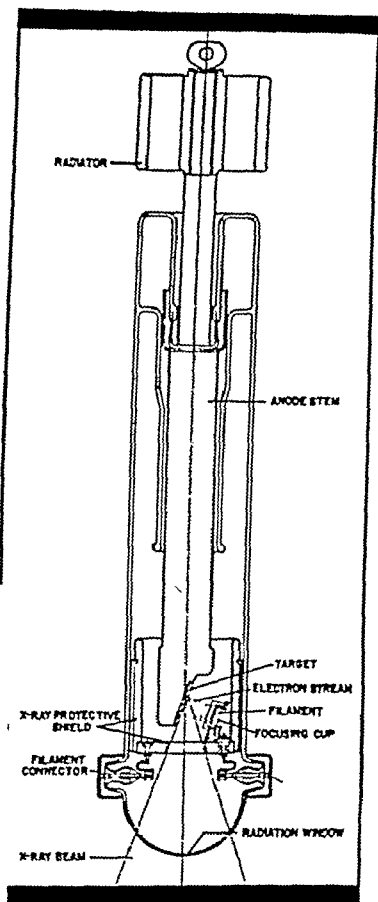
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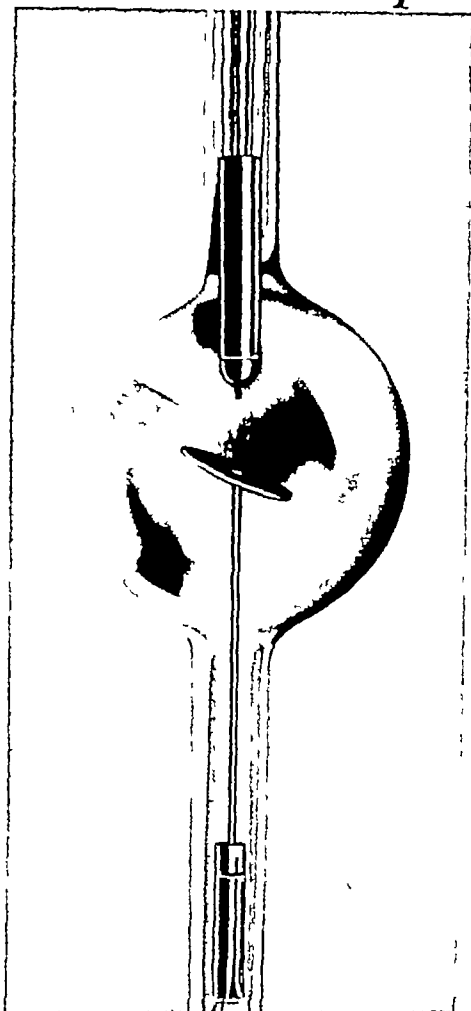
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# 4UD *A New Air-Cooled Coolidge Deep Therapy Tube . . . .*



**T**HIS addition to the Universal series of Coolidge tubes offers higher maximum energy ratings than its predecessor, the 4U, by the use of a larger focal spot. The ratings:

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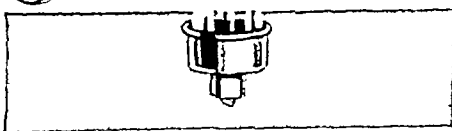
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on constant potential circuit

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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XXII

JUNE, 1934

No 6

FURTHER EXPERIENCE AS TO THE VALUE OF PRE-OPERATIVE IRRADIATION WITH X-RAYS OR RADIUM AND WITH PRE- AND POST-BIOPSY IRRADIATION WHILE SUBMITTING THE SECTIONS TO A NUMBER OF EXPERIENCED SURGICAL PATHOLOGISTS

By JOSEPH COLT BLOODGOOD, M D , *Baltimore*

THE idea of pre-operative or pre-biopsy irradiation is not mine alone. It has been practised by others in a number of the well-known cancer clinics throughout the civilized world. Nevertheless, post-operative and post-biopsy irradiation is the rule, while, from my experience, it should be the exception.

In the "Annals of Surgery" for November, 1932, was published my article read by title before the American Surgical Association in May of that year. The full title was "When should Irradiation with Radium or X-rays Precede Operation, or be Employed without It?"


In this article I quoted the work of Keynes, of St Bartholomew's Hospital, in London, published in the "British Journal of Surgery" for February, 1932. I was much impressed not only by his contribution, but by my visit to his clinic in the previous May. His method of treating inoperable cancer of the breast by interstitial radium salt needles, as illustrated in Figure 1 of my article, was practised quite commonly by a smaller group of surgeons in London when I was there in the Spring of 1932, almost two years ago. There seemed to be no question but that a number of the cases so treated appeared to be clinically well and free from definite recurrences, and a number had passed the two- and three-year limits. I have seen one definite three-year cure in Dr Henry's

Cancer Clinic, in Regina, Canada. I have two such cases of my own—both living and apparently well to-day, three and one-half and two and one-half years, respectively, since treatment.

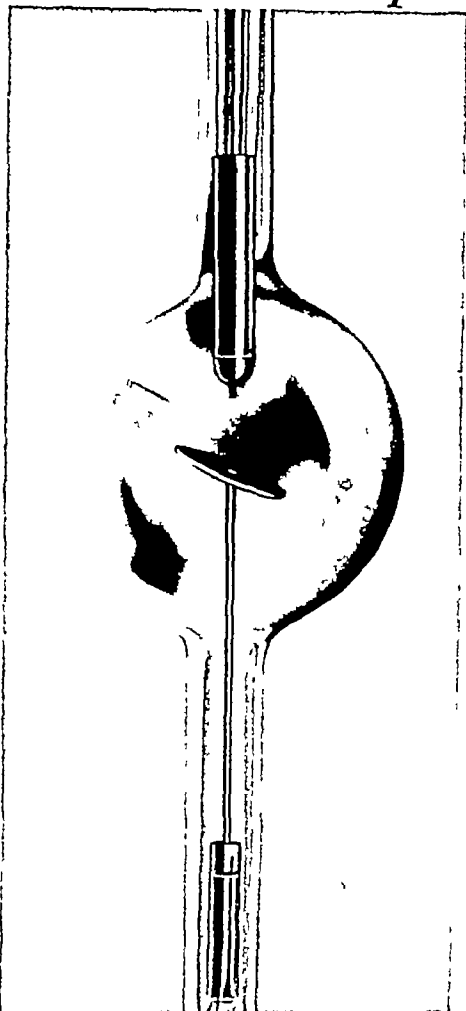
I published a second paper in the "Annals of Surgery" for November, 1933, the title of which was "Pre-operative Irradiation in Cancer of the Breast, with and without Biopsy." Here I confined my studies largely to recent observations in which irradiation was done, not in conjunction with operation, but as a measure preceding the complete operation and when incomplete operations were practically forced upon us by the patient's refusing, or not being physically fit for the complete operation. This paper was read for me by Dr Max Cutler before the Congress of Radiology, held in Chicago in September, 1933.

Since returning from my visit to the cancer clinics in Paris and London, I have interested myself much more in the employment of x-rays and radium as a pre-operative and pre-biopsy measure, and have attempted to establish certain definite rules.

All recurrent tumors—whether operable or not—irrespective of their known pathology, have been given the benefit of a thorough course of irradiation, either with deep x-rays or with radium in some form. There is plenty of evidence to justify



# 4UD *A New Air-Cooled Coolidge Deep Therapy Tube . . . .*



THIS addition to the Universal series of Coolidge tubes offers higher maximum energy ratings than its predecessor, the 4U, by the use of a larger focal spot. The ratings

200 Kv p, 10 ma., continuous—  
or 220 Kv p, 8 ma., continuous—  
on single phase rectified circuits  
other than constant potential

200 Kv p, 8 ma., continuous—  
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Attention is called to the thick tungsten disc and molybdenum shank which replace the *Universal type anode* of the 4U. They are designed and treated to stand up under operating temperatures without danger of mechanical failure, bowing, or gas liberation.

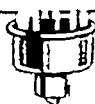
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Ultimately I hope to publish in this Journal further evidence of the essential value of irradiation as the first treatment for recurrence after any type of operation for any type of tumor, even abdominal, before attempting further operative intervention

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In a second paper I hope to bring out some strikingly favorable results after irradiation of inoperable cancers of the rectum This was my first experience with an operable tumor

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pioneers in a few cancer clinics throughout the civilized world attempted it next in late, but apparently operable, cancers Then a few of them ceased operating for cancer of the cervix and substituted irradiation The majority of authorities to-day agree that irradiation with radium and deep x-rays is the treatment that promises most in all types of cancer of the cervix, and the best results are reaching 35 per cent, varying from less than 10 to more than 90 in the four group grades of cancer of the cervix

As in my two above-mentioned previous papers, I emphasize the great value of pre-operative and pre-biopsy irradiation of all bone tumors, and I am now including lesions of the jaw, whether they involve teeth or not, in this rule I will not discuss this further here, because I now have in preparation an article on irradiation of bone tumors, to be presented before the fiftieth anniversary of the Memorial Hospital in New York, and if I can not publish the full article in this Journal there will be an abstract sent to the Editor

Pre-operative and pre-biopsy irradiation of such bone tumors as are suspicious of malignancy on x-ray examination, are pretty well established Just how long one should persist in the irradiation treatment is not yet established, but one must remember that there is danger in too long attempts, as in too short attempts

*Breast Tumors*—In the past two years, due to the increasing number of doubtful breast tumors explored for biopsy in my own clinic, and among those sent to me for diagnosis, I have been forced to take a different view of the former rule of advising the complete operation when the pathologists are in doubt as to the malignant nature of the breast tumor excised and submitted to frozen section in the operating room

I am not yet prepared to advise irradiation before the immediate complete operation when the section shows an undoubted malignant tumor But recently, in special cases, when we have excised the clinically doubtful tumor of very short



this For example, in small cancers of the skin, especially of the face, recurrent after any procedure, the chances of a permanent cure are reduced at least to 60 per cent by excision with a margin sufficient for the primary tumor In a number of these cases there has been no further treatment beyond irradiation I am convinced that this rule should be given careful consideration by operators No harm can be done by proper irradiation in these recurrent cases which are apparently still operable

My most recent example is as follows Nine years ago I excised a lesion about the size of a ten-cent piece, with a margin sufficient for a primary basal-cell cancer of the face It had been present off and on six years and had received inadequate x-ray treatment I have just examined the sections again The small basal-cell cancer has apparently a free margin of uninfiltated normal tissue about it Yet, after more than eight years of an apparently normal scar a little ulcer (about three mm in diameter) has formed, covered with a scab It has not healed with daily applications of warm water and soap followed by alcohol and petrolatum It is still very small and could be excised with a margin larger than the scar without leaving an unsightly new scar It is my opinion that the majority of my colleagues in operative surgery would operate again But I have sufficient evidence to show that this patient's chances of a permanent cure are better with irradiation, irrespective of whether excision is performed or not, and I propose to repeatedly bring before such of my colleagues as are responsible for tumor work the idea of the rule in all recurrent tumors, irrespective of their pathologic nature (even lipoma and dermoid cysts), to give irradiation first

There is a second recurrent tumor that establishes a new rule in regard to adamantinoma carcinoma of the body of the lower jaw This patient came under observation six months ago with a scar 2.5 cm in length, beginning 2 cm in from the angle

of the jaw One could easily see and feel an expansion of the bone beneath this scar, and in the x-ray film one could see numerous light areas mixed with bone areas occupying the body of the jaw beneath and beyond the scar I was also sent a section removed from this jaw in 1929, almost four years ago, and this showed an adamantinoma carcinoma in scar tissue When this patient was operated upon in 1929 it was a recurrent tumor after operations in 1915 and in 1921 So it is almost twenty years since the first tumor was curetted At each operation curetting was performed After the operations in 1921 and 1929, x-ray therapy was given Subsequently, as I said above, a section, obtained at the first operation, was sent to me The microscopic picture is typical of adamantinoma carcinoma, without the scar tissue which predominates in the last section

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nally Three months later we excised the breast and grafted skin I have discussed this case in detail in two previous papers No glands could be palpated, none were removed, because the patient was distinctly a bad operative risk I have not seen this patient since her stormy recovery from the operation, but both the woman and her physician write me that her general health is excellent and there is no sign of recurrence I am not confident that anything is gained by the removal of the breast with a large area of skin As previously reported, although we found areas of cancer in the stained sections, there was no growth of cancer cells in the cell culture by Dr and Mrs Gey

*Pre-operative Irradiation in Operable Cancer*—As far as I can learn, the majority of surgeons of large experience prefer the complete operation without delay or within a few days after a short and, in my opinion, incomplete pre-operative irradiation I believe to-day that when one selects pre-operative irradiation for operable, clinically distinct cancer of the breast, the irradiation should be of the same intensity and the same duration as for inoperable cancer of the breast This is a point that can not be settled by anyone's experience to-day I am selecting these cases among patients of extreme age, or who are very bad operative risks, or who refuse operation—it is a small group So far, all results have been favorable At the present time in my clinic the majority of cases of clinical cancer of the breast which are distinctly operable and clinically favorable are subjected to immediate operation Those clinically unfavorable are irradiated first As far as I can make out, no case irradiated first has lost any chances of a permanent cure by operation But for comparison there must be two groups of operable cancer of the breast, clinically malignant—those operated on without pre-operative irradiation, and those with such irradiation

*Clinically Doubtful Tumors of the Breast*

—In my observation this group has been increasing more than any other As a

rule, the duration of the breast symptoms has been less than one month There is a single, definite, palpable lump, which if larger than a twenty-five-cent piece, transilluminates dark, or, if smaller, transilluminates light or doubtful In any event, the operator feels that this palpable lump should be explored and removed (unless it proves to be a blue-domed cyst), being submitted to immediate frozen section in the operating room, when this is possible

These tumors, distinctly benign in gross appearance and frozen section, at exploration, fall into the following classes The common blue-domed cysts, the distinct galactoceles and chronic breast abscesses, less frequently, the intracystic papillomas, and the distinctly encapsulated fibroadenomas or intracanalicular myxomas The type of tumor increasing to-day is the non-encapsulated solid tumor, most of which are areas of chronic cystic mastitis, and some are chronic lactation mastitis without pus Many of these tumors are very difficult to distinguish from cancer in the frozen or permanent section, especially when the patient is pregnant or lactating They must be placed in a group called "microscopically doubtful tumors" I have discussed them in the "Archives of Surgery" for 1921 (III, 445), and, more recently, in the "American Journal of Cancer," 1932 (XVI, 103)

The new point I wish to make is this The majority of the microscopically doubtful tumors exposed by surgeons and surgical pathologists of average ability and experience will ultimately prove to be benign There is little or no risk in excising such a tumor, waiting for the wound to heal, and then subjecting it to a thorough course of irradiation During this period sections should be submitted to a number of pathologists When there is disagreement among them, the chances are that the tumor is benign and nothing further need to be done If the tumor is agreed upon as being malignant, the majority of surgeons to-day will prefer to follow the pre-operative irradiation by the complete

duration and found it to be microscopically cancer, I have, for special reasons, submitted the patient to irradiation rather than to the complete operation, and in some of these cases the complete operation has not yet been performed. This study is approaching its completion and is to be presented before the Surgical Section of the American Medical Association. I am giving here a brief abstract of this paper, which will ultimately be published in the "Journal of the American Medical Association."

*Breast Tumors in which it Seems Wiser to Perform Irradiation First* *Cancer en cuirasse*—This can be recognized clinically by the increased weight and the edema of the breast, the pig skin over the breast, and a very peculiar redness of the skin of the breast, whether it is involved or not with pig skin. When I contrast the results in the patients whom we first saw with cancer *en cuirasse*, and in whom the condition was distinctly inoperable, with those in more recent years in whom the condition was operable and for whom most complete operations were performed with the cautery or the electric needle, followed by post-operative irradiation, I find that the first group, when left absolutely alone, were more comfortable up to the time of death than the second group, subjected to complete operation followed by irradiation. Three and one-half years ago I asked my colleague, Dr. Max Kahn, to irradiate a patient with cancer *en cuirasse* which, although extensive, was still operable. This patient is living to-day, almost three years and six months. She suffers no discomfort, there is great improvement in the local condition.

A second case of cancer *en cuirasse*, distinctly operable, was referred to Dr. Burnam for irradiation. The weight and edema of the breast have disappeared, a distinct lump in the upper inner quadrant and a few palpable glands in the axilla have disappeared to palpation, the pig skin and erythema have almost gone. After some weeks of treatment, she began to have pain in the cervical and thoracic

vertebrae, and x-ray examination revealed metastasis. The discomfort from this has been entirely relieved by the irradiation. There is no doubt but that these two patients with cancer *en cuirasse* are much more comfortable than any other two subjected to complete operation and post-operative irradiation.

In the past two years two clinically benign breast tumors have been excised because frozen sections in the operating room were diagnosed not only cancer, but graded IV, acute carcinoma. There were no clinical evidences of cancer *en cuirasse*. There was metastasis to the base and mid-glands. On account of the grading of the tumor, the electric cautery was employed in the dissection and a large area of skin removed, to be followed by grafting. Very quickly, in spite of post-operative irradiation, there developed in the skin about the grafted area first skin metastasis, then cancer *en cuirasse*. Both patients succumbed to the disease within two years, suffering greatly meanwhile. Therefore, if, at the exploratory excision, the sections of the tumor removed are definitely cancer and positively of Group IV, acute carcinoma, the wound should be cauterized with the thermal cautery and closed with drainage, and the breast, axilla, and supraclavicular area subjected at once to deep x-ray therapy, or the four-gramme pack, or some type of interstitial irradiation. I believe it is safer not to perform the complete operation in cancer *en cuirasse*.

*Inoperable Cancer of the Breast*—Everyone now seems to agree that this group should be subjected to irradiation first, and that there should be one or more courses of such irradiation (I will not discuss in this paper the methods of irradiation, except that one named for Coutard). I have one such case, now living two years. The treatment was given by Dr. H. A. Kelly and his son and consisted in the implantation of radon seeds, following the method of Mr. Keynes, of England, in addition to radium emanations in larger amounts applied exter-

# COMBINED SURFACE AND INTERSTITIAL RADIATION IN THE TREATMENT OF MAMMARY CANCER<sup>1</sup>

By ALBERT SOILAND, M D , *Los Angeles*

**R**ADIATION therapy—that ever-changing, ever-progressing, and always fascinating branch of medical science—demands new recognition as a therapeutic arm of major importance in the management and treatment of cancer of the breast. This disease, since its earliest recognition, has been considered as a purely surgical problem. This viewpoint, however, is now being challenged from observers in different parts of the world. From the Continent, several well-known radiologists assure us that either x-rays or radium, applied according to their own particular method of procedure, gives results which are equal to, or better than, those reported by surgery. While the significance of this opinion has not yet been accepted openly in America, there are, nevertheless, a considerable number of individuals here who are slowly but surely forcing upon their surgical confrères a realization that both x-rays and radium are, at least, strong allies of, if not actual substitutes for, surgery in the treatment of this devastating disease.

The most recent report of Hermann Wintz,<sup>2</sup> one of the staunch supporters of radiation therapy at Erlangen, Germany, gives results in the treatment of carcinoma of the breast by x-rays alone over a period of fifteen years, and presents conclusions which demand the attention of all those interested in carcinoma of the breast. It would appear to the open-minded that Wintz has secured sufficient evidence from his work to place his results on a parity with, or even better than, those obtained in the best of surgical circles. In fact, Howard C. Taylor, Jr., who reviews<sup>3</sup> his work, states in conclusion

"This paper is an important one on account of the large number of cases, the invariable microscopic proof of diagnosis, and the manner in which the statistics have been compiled. Wintz himself is conservative in the statement of his conclusions, although he points to the superior results obtained in Groups II and III (Stenthal) to those obtained in surgery. Nevertheless, one cannot but conclude that, can the figures of Wintz be duplicated in other clinics, the simple surgical treatment of breast cancer will have difficulty in maintaining its present position. However, such duplication has yet to be observed.

"The emphasis upon the unreliability of statistics on breast cancer as compared to uterine cancer, in which the principle of reporting five-year cures on the basis of all cases observed (absolute cure rate) has been universally adopted, appears very pertinent."

So much for the x-ray side of the question. Now let us cross the Channel and observe what one of our British colleagues, Geoffrey Keynes, says on "The Radium Treatment of Carcinoma of the Breast,"<sup>4</sup> as ably abstracted by Howard C. Taylor, Jr.<sup>5</sup>

"The problem in the treatment of carcinoma of the breast by radium is exactly the same as in the operative treatment—how completely to extirpate the cells of the primary growth and all secondary growths that may conceivably be accessible. The correct principles for surgery, which are now standardized, are removal of (1) the whole mammary gland with the overlying skin for as great a distance as possible around the primary growth, (2) the underlying fascia and pectoral muscles, (3) the axillary lymph nodes and the channels from the breast in continuity. Attempts to extend the operation further, while occasionally successful, are too dangerous for general applicability.

"Until recently most radiation treatment was confined to inoperable cases, and the London Radium Institute was able to report that 11 out of 98 of these cases, hopeless as far as surgery was concerned, survived for five years. Keynes' attempt to treat carcinoma

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

<sup>2</sup> Deutsche med. Wchnschr., 1931.

<sup>3</sup> Am. Jour. Cancer, September 1932.

<sup>4</sup> British Jour. Surg., 1932.

<sup>5</sup> Am. Jour. Cancer, September, 1932.

operation. And there also will be a difference of opinion how long one should wait. I am rather in favor of completing at least the first course of irradiation before undertaking the complete operation, and waiting at least two or three weeks to let the effects of the irradiation subside. This group is becoming very common in my observation, and, so far, no individual has suffered by the delay incident to the irradiation, while many breasts have been saved.

In the second group, the operator and his pathologist at the exploratory incision or excision will be of the opinion that the lump in the breast is malignant. The majority of surgeons and, I think, radiologists to-day favor that the complete operation be performed at once. I am gathering evidence which shows that nothing is lost and something very valuable to the patient may be gained by the simple removal of the tumor in such cases, to be followed by irradiation of the same type and for the same period as for a clinically malignant tumor.

I find that there is considerable difference of opinion among radiotherapists as to the period of time between the excision of the tumor only and the irradiation. My associate, Dr. Curtis Burnam, is inclined to wait a couple of weeks, giving

the wound a chance to heal. It is true, the wound is apt not to heal when irradiated at once, and Dr. Burnam fears an infection which will interfere with irradiation. We have tried both immediate and postponed irradiation. I am rather inclining to the immediate irradiation, especially in a smaller group of cases in which the sections show definite malignancy.

This entire problem of irradiation in operable malignant tumors of the breast is unsettled and needs much further study. I wish to emphasize that when a breast tumor is clinically benign and when, at operation, it is microscopically doubtful, the tumor should be excised with a margin of healthy breast tissue, the wound closed, and there should be immediate irradiation while waiting for the section to be submitted to a number of pathologists. This irradiation should continue on the supposition that the tumor is malignant. If ultimately the pathologists disagree or conclude that it is non-malignant, nothing more need be done. If they conclude that it is malignant, it is the responsibility of the surgeon to choose between further irradiation and the complete operation.

I am rather inclined to the view that ultimately it will be irradiation.

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with a minimum of by-effect or untoward late sequelæ

The immediate object in all cases is to employ sufficient radiation to destroy all malignant cells, otherwise our ultimate objective, as well as time and effort, would be lost. With this aim in mind, we began many years ago to plan the foundation of an effective treatment combination for carcinoma of the breast in which both x-rays and radium were to be employed in various experimental combinations, and we refer to the following historical outline as a reasonable justification for such action.

During the first decade of clinical x-ray experimentation (1896-1906), I held the opinion that surgery should almost always come first and that the x-rays should follow immediately, and be applied, if possible, to the open operative field. Only one local surgeon supported me at that time, so there was no opportunity afforded to carry on any extensive investigation. Two cases were, however, reported.<sup>7</sup> Later, my old respected and late lamented friend, Emil Beck, of Chicago, conceived the idea of making all breast surgery for cancer on the wide open plane, radiating the denuded area intensively after removal of the breast, and permitting the wound to heal slowly by granulation. The lesson taught by this experience unquestionably demonstrated the carcinolytic action of x-rays and verified the *rationale* of pre-operative radiation.

The second decade up to 1915-16 witnessed great improvement in x-ray apparatus, as well as many refinements in radium applicators. Methods for the measurement of wave lengths and dosimeters of varying types were offered to help standardize radiation therapy, which was assuming international importance as a medical specialty. It was during this period that I began seriously to advocate pre-operative x-radiation. Evidence was rapidly accumulating to show that one could not afford to go into the practice of

clinical radiology unless willing to earnestly apply oneself in an attempt to learn the intricacies and master some of the angles of this rapidly growing and by no means simple science. Those who have been willing to spare the time, the money, and the effort in this endeavor are well satisfied with the results which have accrued. Many, however, have neglected to follow the path rigorously, and this accounts in no small degree for much of the adverse criticism to which the science of clinical radiology has been subjected. Nevertheless, during the following decade and down to the present time, the technic for treatment of cancerous disease by x-rays and radium has steadily advanced, and greatly improved results are now apparent, even in carcinoma of the breast.

About 1917, at the end of the second decade, there appeared upon the market radium element needles, made of iridium steel, which we began to utilize in some recurrent breast cancer nodes. These gave immediate results which were highly encouraging, but later we learned to our chagrin that the filter value of the needle covering did not prevent implantation necrosis, so we quickly discontinued their use. It was not until the end of the third decade (about 1927) that the platinum needle was substituted and we then resumed this type of radium service. Meanwhile, having become intensely interested in the possibilities of combined radiation as a major treatment for breast cancer, and having already acquired a not inconsiderable amount of experience, it appeared logical to assume that the earlier the x-ray or radium energy was directed in sufficient quantity to a cancer-bearing area, the more favorable would be the patient's outlook. We began more earnestly to study and apply this angle to our work, and subsequent events have assured us that it is bearing fruit.

Skepticism regarding the results claimed by radiologists always reverts to the fact that no convincing statistics are available which are prepared as accurately as the five-year records of pure surgery. This

<sup>7</sup> Plea for Combining the X rays with Surgery in Mammary Carcinoma. Southern Calif Practitioner, July, 1904.



of the breast began in 1922 with some recurrent cases in which it was found that, with small amounts of radium in platinum needles with a wall thickness of 0.5 mm, it was possible to obtain one cure among seven patients. The others died within a comparatively short time from metastases in other parts of the body. If cures could be obtained in a recurrent growth, Keynes asked, why not also with a primary growth? In 1924 he treated such a primary tumor with the result that the patient is still alive, despite several series of local recurrences.

"A table is appended analyzing the results of the 171 cases, the tabulation of the results showing that in 9 with a Class I tumor, 78 per cent are alive at the end of three years, of those with Class II tumors, 36 per cent are alive at the end of three years, and of those with Class III tumors, which is the larger inoperable group, 46 per cent are alive at the end of three years. The latter result is most interesting, because these patients cannot be helped by surgery. In any case, the numbers are small, and the final re-survey must be made at the end of five years.

"The author concludes that in general the results of radium treatment compare favorably with those obtained by pure surgery. He does not claim that radium treatment should supplant surgery, however, but that it should have a definite place in the treatment of carcinoma of the breast, and should often be used instead of, or in combination with, surgery, according to the individual circumstances. For very advanced or inoperable tumors, radium is the treatment of choice. For the earliest and smallest tumors, radical operation is unnecessary. Excellent results can be obtained by radium alone, or radium combined with conservative surgery."

Here we have examples of two outstanding clinicians, one in Germany obtaining results with x-rays alone which compare favorably with the best surgical statistics, and one in England achieving the same by the use of radium. Would it not be logical, therefore, to assume that by an intelligent combination of both these agents, even better results might be anticipated? We believe it would, and we shall, therefore, enlarge briefly upon the subject.

X-ray, as we view it, is necessarily a type of on-the-surface treatment, that is, every application must reach its quest through some overlying skin or surface covering. Radium, on the other hand, is

more serviceable when it can be placed in direct contact with, or into, the neoplastic area, hence its employment interstitially.

For a number of years it has been the custom of our own clinical group to apply our knowledge of the individual action of these two agents and use them accordingly in all our breast cancer work. Our technique has been described elsewhere\* and will be omitted from the present discussion, except to state that with radium implantation it becomes necessary to group the patients according to type of lesion, size of breast, and degree of involvement. Very large, fatty, or pendulous breasts are not implanted unless tumor is localized and within reasonable limitations as to size. Otherwise such a breast is subjected to the routine sterilizing course of x-radiation and then removal by the electro-tome, at which time the radium implantation is completed in the adjacent tissues and gland chains.

When any large quantities of x-rays are directed to a tumor through the lung-fields, we have always been apprehensive about fibrosis of the chest structures. Experience shows us, however, that this danger has been considerably overestimated as it occurs only in a comparatively limited number of patients, and then most usually in cases in which inflammatory processes have befogged the clinical picture. It is naturally advantageous to the patient, however, to avoid as much unnecessary radiation as possible, hence, we gladly availed ourselves of Dr. Holfelder's recent suggestion and cross-fired the breast areas by the so-called tangential method which was so well described by him. With care and a little ingenuity one can now irradiate a breast field from three or four angles and obtain a marked increase in the effective depth dose with x-radiation, bringing a definite benefit to the patient,

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\* The Management of Breast Cancer, Jour. Am. Med. Assn., March 5, 1932, XCVIII, Experiences in Interstitial Irradiation of Carcinoma of the Breast. Am. Jour. Roentgenol. and Rad. Ther., August, 1932, XXVIII, Management of Cancer of the Breast, Southwestern Med., December, 1932.

Name Age		Year	Location	Classification (Steinthal)	Reactions and Notes as of Sept 1, 1933	
26	B , 70	1932	Left breast	S I	Developed node which was needed later Breast and axilla—no palpable disease at present Living in 1933	Alive 1½ years
27	M , 64	1932	Right breast	S III	Breast almost normal, except adherent scars to ribs Living in 1933	Alive 1 year
28	W , 52	1932	Left breast and axilla	S II	Small palpable mass in breast yet Axilla normal Living in 1933	Alive 1 year
29	F , 60	1932	Left breast	S I	Breast normal Living in 1933	Alive 1 year
30	C 72	1932	Left breast and axilla	S II	Massive recurrence Biopsy showed adenocarcinoma Died in 1932	Alive 6 mos
31	R , 72	1932	Left breast and axilla	S III	Rapid extension of disease Died in 1932	Alive 4 mos
32	W , 52	1932	Right breast and axilla	S II	Breast normal Living in 1933	Alive 1 year
33	S , 65	1932	Right breast, axilla, and both supraclavicular areas	S III	Has metastasis to spine Axilla normal and supraclavicular areas normal Living in 1933	Alive 1 year
34	L , 59	1932	Right breast	S I	Breast feels normal, but nipple somewhat firm—may need more treatment Living in 1933	Alive 1 year
35	S , 62	1932	Left breast and axilla	S II	Small, firm nodule still present Axilla normal Living in 1933	Alive 1 year
36	B , 73	1932	Right breast and axilla	S II	Breast normal Axilla—no disease. Living in 1933	Alive 6 mos
37	R , 46	1932	Left breast and axilla	S II	Breast and axilla—no palpable disease Living in 1933	Alive 6 mos
38	V , 65	1932	Right breast and axilla	S III	Temporary improvement Massive recurrence Biopsy showed adenocarcinoma Died in 1933	Alive 4 mos
39	P , 42	1932	Right breast	S I	Breast normal Living in 1933	Alive 6 mos
40	M , 65	1932	Right breast, axilla, and supraclavicular area	S III	Still has node in supraclavicular area but breast apparently normal Living in 1933	Alive 6 mos
41	A , 51	1932	Left breast and axilla	S II	Breast feels normal Axilla shows no palpable disease Living in 1933	Alive 6 mos

## SUMMARY OF ALL CASES TREATED

1	Living 6 months to 3 years free from cancer	31
2	Lost trace of patient	1
3	Died of cancer	6
4	Died of intercurrent disease	3
Total		41

is quite true, for radiological technic has developed so rapidly and changed so radically that no five-year statistical records of value have been compiled those which have accompanied surgical statistics are misleading and quite unfair to radiology. Nevertheless, we are convinced that radiation has materially added to the five-year clinical cures in carcinoma of the breast,

and if we are to believe the evidence which has accumulated during the past three or four years, we must agree with Keynes and Wintz that radiation alone is superior to pure surgery, in fact, our own experience with short wave x-rays and interstitial gamma radiation has shown this in no uncertain manner.

In conclusion, I beg to submit a pre-

	Name Age	Year	Location	Classification (Steinthal)	Reactions and Notes as of Sept 1, 1933	
1	C, 68	1929	Left breast and axilla	S III	Breast—no palpable disease Metastasis to right lung Died in 1931	Alive 2 years
2	K, 63	1929	Left breast and axilla	S II	Breast—no palpable disease Metastasis to spine Died in 1932	Alive 3 years
3	B, 72	1930	Left breast and axilla	S II	Coronary thrombosis following operation on breast Disease not controlled by radiation Adenocarcinoma found in breast tissue Died in 1932	Alive 2 years
4	B, 46	1930	Left breast and axilla	S II	Fibrosis of treated area No pal- pable disease Living in 1933	Alive 3 years
5	D, 49	1930	Right breast	S III	No palpable disease Living in 1933	Alive 3 years
6	H, 55	1930	Right breast	S II	No palpable disease Living in 1933	Alive 3 years
7	B, 51	1930	Right breast and axilla	S II	Breast removed and found to be the seat of a carcinoma This was an unusually large breast Living in 1933	Alive 3 years
8	McN, 39	1930	Right breast and axilla	S III	Disease still present in breast Died of paroxysmal tachycardia in 1930	Alive 4 mos
9	E, 43	1930	Left breast, axilla and supraclavicular area	S III	Nodular palpable mass still pres- ent in breast Axilla and supra- clavicular areas normal Living in 1933	Alive 3 years
10	N, 65	1930	Right breast	S I	No disease Living in 1933	Alive 3 years
11	E, 62	1930	Right breast	S I	No disease Section before im- plantation showed adenocar- cinoma Living in 1933	Alive 2½ years
12	T, 54	1930	Right breast	S I	Breast normal Living in 1933	Alive 2½ years
13	K, 44	1931	Left breast, axilla, and supraclavicular area	S III	Breast normal Some neuritis in arm Axilla and supraclavicu- lar areas normal Living in 1933	Alive 2 years
14	C, 70	1931	Right breast	S II	No disease palpable, but breast deformed by former disease Living in 1933	Alive 2 years
15	E, 60	1931	Left breast	S I	Breast normal Living in 1933	Alive 2 years
16	W, 47	1931	Right breast and axilla	S II	Breast normal Axilla negative Living in 1933	Alive 2 years
17	S, 77	1931	Left breast and axilla	S II	Mass still palpable Axilla—no disease Living in 1933	Alive 2 years
18	D, 70	1931	Left breast and axilla	S II	Breast normal Biopsy showed squamous-cell carcinoma Axilla normal Living in 1933	Alive 2 years
19	R, 65	1931	Left breast and axilla	S II	Breast normal Biopsy showed adenocarcinoma Axilla—no palpable disease Living in 1933	Alive 2 years
20	W, 54	1931	Left breast and axilla	S III	Metastasis to liver Breast nor- mal except for deformity Died in 1932	Alive 1 year
21	R, 51	1931	Right breast and axilla	S IV	Metastasis to brain Biopsy showed adenocarcinoma Breast negative Node palpable in axilla Died in 1932	Alive 6 mos
22	T, 45	1931	Left breast and axilla	S II	Lost trace of patient	
23	W, 47	1931	Right breast	S I	Breast normal Living in 1933	Alive 2 years
24	J, 46	1932	Right breast	S I	Breast normal Living in 1933	Alive 1 year
25	H, 61	1932	Right breast	S I	Breast normal Living in 1933	Alive 1 year

## THE RATIONALE OF X-RAY TREATMENT IN ENCEPHALITIS LETHARGICA<sup>1</sup>

By S A GOLDBERG, PH D, M D, C F BAKER, M D, and J W HURFF, M D,  
*Presbyterian Hospital, Newark, New Jersey*

THE essential lesion in encephalitis lethargica and in poliomyelitis is a perivascular mantling by small round cells. It occurred to the senior author that the symptoms are largely due either to pressure or to circulatory disturbance produced by the perivascular lymphocytic infiltration. Since these cells are highly sensitive to irradiation, it was thought that x-radiation in minute doses should be the logical treatment in these conditions. This is the first opportunity that has presented itself to determine the efficacy of such treatment. The results obtained are so striking that we deem it worth while to report them.

### CASE REPORTS

Case 1 D T, a white girl, aged 17 years, admitted to the Presbyterian Hospital on Jan 26, 1934, suffering with headache, drowsiness, nausea, and nasal discharge. She had had a chronic discharging ear since infancy. In childhood she had had measles, whooping cough, chicken pox, and frequent colds associated with persistent bronchial coughs. In July, 1931, she was treated for general pansinusitis.

The present illness began suddenly on Jan 24, 1934, with headache in the morning, followed by a semicomatose condition in the afternoon. She vomited, had a profuse muco-purulent nasal discharge, and a slight facial paralysis.

On admission to the hospital, the physical examination revealed an extremely drowsy patient, with tinnitus, slight internal strabismus, slight left facial paralysis, negative visual fields and fundi, temperature 99.6° F, pulse 78, respirations 20. The following day a lumbar puncture was performed, about 4 c c of clear,

colorless fluid being removed under normal tension. The cell count was 10 per cubic millimeter, all lymphocytes. The globulin was not increased, the sugar content was normal, micro-organisms were not seen nor was there any growth in the culture. Roentgenograms of the sinuses showed very marked cloudiness of both antra, anterior and posterior ethmoids, and sphenoid sinuses. The urinalysis was negative. The patient continued to have severe headache, occasional projectile vomiting, purulent nasal discharge, a productive cough, anorexia, and developed a persistent rigidity of the neck. The second day after admission, under local anesthesia, large polypoid masses of granulation tissue were removed from both nostrils to facilitate drainage. The following day a second lumbar puncture showed slightly cloudy fluid under normal tension. The cell count was 375 per c mm, consisting of a few erythrocytes, lymphocytes 75 per cent, neutrophils 21 per cent, endothelial cells 4 per cent. Acid-fast or other micro-organisms were not seen. The culture showed no growth. Then both frontal sinuses, the right ethmoid and sphenoid sinuses, which were filled with granulations and pus, were opened and drained but not curetted. The culture of the pus showed a growth of short chain streptococci. The fourth day after admission her condition remained unchanged. She became very restless, had to be restrained from trying to get out of bed, cried out occasionally, vomited four times, took fluids scantily, and was still drowsy.

On January 31, in addition to the former symptoms, for the first time she showed definite weakness of the left arm and leg. She was semicomatose but could be roused. A lumbar puncture was done but no fluid was obtained. On February 1 she had projectile vomiting, screamed fre-

<sup>1</sup> Accepted for publication April 12, 1934.

limentary chart of reactions under our new technic, not as a statistical report, but as one sufficiently encouraging to warrant a continuation of this study and effort. This report does not include patients irradiated since January 15 of the present year [1933], nor patients upon whom elec-

trosurgical methods have been employed. I desire to acknowledge the faithful work of my radiological associate, Dr William E Costolow, and my surgical associate, Dr O N Meland, without whose continued co-operation my own limited efforts would have been futile.

1407 S Hope St

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patient is mentally alert and resuming his former duties

Case 3 N L, a white male, age 25, was admitted to the Presbyterian Hospital at 7 30 P M, March 16, 1934, in a semi-comatose condition. The onset of the present illness began suddenly in the morning, with a severe frontal headache. Physical examination on admission revealed a drowsy, restless patient, with opisthotonos, and no abnormal reflexes. A lumbar puncture showed bloody fluid, under marked tension, with normal sugar content and negative culture. The smear appeared like a blood smear. The next day the condition of the patient was worse. His headache continued and he vomited occasionally. Examination showed unequal pupils, rotary nystagmus, normal visual fields and fundi, bilateral Kernig's sign, exaggerated knee jerks, and marked ankle clonus. The spinal fluid appeared similar to that of the day before. X-ray examination showed marked cloudiness of the ethmoid and sphenoid sinuses. A cisterna puncture in the evening also showed bloody fluid. The blood count was 10,400 leukocytes, polymorphonuclears 87 per cent, and lymphocytes 13 per cent. The urinalysis was negative. Therefore, a presumptive diagnosis of subarachnoid hemorrhage was made. Hypertonic glucose was administered intravenously and magnesium sulphate by mouth, to relieve intracranial pressure. For three days the condition of the patient remained unchanged and the headache, restlessness, and drowsiness continued. On March 20 a cisterna puncture showed the spinal fluid under marked tension, containing considerably less blood than at the time of the previous examination. On March 26 the patient vomited, was irrational, showed rigidity of the neck, a Babinski on the right side, absent lower abdominal reflexes, dilated pupils, and normal fundi. A cisterna puncture showed slightly cloudy fluid, under normal tension, with normal sugar content, 65 cells per c mm, lymphocytes 94 per cent, neutrophils 4 per cent, endothelials 2 per cent, many erythrocytes

Micro-organisms were not seen in the smear or culture and the Wassermann reaction was negative. March 27 the patient continued to have headache, was drowsy and incontinent, and vomited. March 28 the blood count showed 7,300 leukocytes, polymorphonuclears 49 per cent, lymphocytes 37 per cent, eosinophils 7 per cent, and monocytes 7 per cent. For the first nine days the temperature ranged between 100° and 102° F. March 31 a spinal puncture showed very slightly xanthochromatic fluid, under moderately increased tension, with normal sugar content, 93 cells per c mm, of which 97 per cent were lymphocytes, 1 per cent neutrophils, and 2 per cent endothelial cells. A diagnosis of encephalitis was made because of the increased number of lymphocytes in the spinal fluid, and an x-ray treatment was given. The dosage was small, being the same as that given in the two previous cases. Eighteen hours later the patient was markedly improved, the next day he appeared well, could talk rationally, and had no headache. A second x-ray treatment was given 48 hours after the first. A spinal puncture the following morning showed clear, colorless fluid, under normal pressure. There were 74 cells per c mm, 98 per cent lymphocytes, 2 per cent endothelial cells, normal sugar content, and slight increase in globulin.

#### COMMENT

The diagnosis of encephalitis lethargica is based upon objective symptoms of drowsiness, deranged mentality, and signs referable to lesions in the basal nuclei. When, in such a case, the clear spinal fluid shows an increased number of lymphocytes, increased or normal globulin content, and normal sugar content the diagnosis of encephalitis lethargica is established. It is differentiated from meningismus produced by toxic irritation, by the cytologic findings in the spinal fluid. In meningismus the cell content of the fluid remains normal.

quently, was very restless for short periods, slept the rest of the time and complained of frontal head pains. Hypodermoclyses were frequently given. On February 2 a fourth lumbar puncture showed clear, colorless fluid under normal tension. The cell count was 62 per c mm, including an occasional erythrocyte, lymphocytes 99 per cent, neutrophils 1 per cent. Microorganisms were not seen. During the next four days there was no particular change in her condition. During the course of her illness she ran a low grade temperature ranging between 98.6° and 100° F. On February 7, x-ray therapy was first applied. Following it she was irrational, had to be restrained, screamed, and did not appear to be alert mentally. This was considered as being a possible reaction from the irradiation. The next day she held a cup with her left hand for the first time since her illness began, and generally showed marked improvement. X-ray treatments were given on February 7 and February 10. A lumbar puncture on February 13 showed clear, colorless fluid under normal tension, with 12 cells per c mm, all lymphocytes. Globulin was not increased, sugar was normal. She was discharged on February 14, symptom-free. Three more x-ray treatments at intervals of 72 hours were given at the office. Spinal puncture on April 5 showed clear, colorless fluid under normal tension with 2 cells per c mm, globulin not increased, sugar content normal. She is apparently as bright mentally as she was prior to this illness.

Case 2. T. M., a white male, age 53, was admitted to the Presbyterian Hospital on March 15, 1934, with symptoms of psychosis of two weeks' duration. Prior to admission he had been under observation in another institution. There his condition became progressively worse until it appeared hopeless and his family considered having him admitted to a psychopathic institute. Examination of the spinal fluid then showed clear, colorless fluid, under normal tension, containing 60 cells per c mm, including lymphocytes, poly-

morphonuclears, mononuclears, slightly increased globulin, normal sugar content, and negative Wassermann reaction. Urinalysis showed the presence of a trace of albumin and a moderate number of leukocytes. Physical examination showed cardiac arrhythmia, normal reflexes, negative visual fields and fundi. A diagnosis of cardio-nephritis was made.

On admission to this hospital he could only mutter in an unintelligible whisper. He showed neck rigidity, restlessness, drowsiness, and disorientation. A lumbar puncture showed clear, colorless fluid, under normal tension, containing 9 cells per c mm, all of which were lymphocytes. The globulin was not increased and the sugar content was normal. The blood urea was 20 mgm per 100 cubic centimeters. The blood Wassermann and Kahn tests were negative. A diagnosis of encephalitis associated with a cardiovascular condition was made. The next morning the first x-ray treatment was given. The following afternoon the patient showed slight improvement, being able to talk a little more distinctly. A second x-ray treatment was given 72 hours after the first. The following day the patient showed marked improvement. When the attending physician entered, the patient exclaimed "Meet Thomas M. I haven't been Thomas M. for a long time, but now I am, the same as I was before my illness." His general condition bore out this statement. Two more x-ray treatments were given, 48 hours apart, after which the patient was discharged, apparently free from any mental symptoms. The blood count before admission showed leukocytes 17,200, neutrophils 78 per cent, lymphocytes 14 per cent, monocytes 6 per cent. During the treatment the number of leukocytes fell from 15,500 to 12,300, and the polymorphonuclears fell from 69 to 58 per cent, while the lymphocytes rose from 21 to 30 per cent. The patient's temperature tended toward subnormal, ranging between 96.6° and 99.6° F. The x-ray dosage was the same as that used in the first case. At the present writing the

ment of other conditions, in this disease only minute doses are necessary. It is recommended that caution be observed to prevent too rapid destruction of lymphocytes, the development of toxemia, and the possibility of harmful immediate effects which would tend to discredit the method and prevent its more general application.

Because of the similarity of the lesions in poliomyelitis and Landry's paralysis, this treatment should result in beneficial effects in these conditions. We think that the dosage should similarly be very small at first and the areas to which it should be applied would depend upon the regions involved.

In the three cases reported herein this method of treatment certainly shortened the duration of the illness and the period of hospitalization. Because of the removal of the pressure before permanent damage was done to the nerve cells, the treatment certainly obviated the devastating post-encephalitic effects.

We are now attempting to treat cases with a post-encephalitic syndrome of long duration. While we do not expect any beneficial results, on account of permanent

damage already done, we feel this treatment should be given a trial.

It has been predicted by others that the ultimate value of radiation may not be in the treatment of malignancy but in the cure of many acute or subacute diseases. It is hoped that we have added another to the slowly growing number of lesions responding to radiation.

#### SUMMARY

1 A new application of roentgen therapy has been tried for the relief of pressure or circulatory disturbance in the central nervous system produced by perivascular lymphocytic infiltration.

2 Rapid absorption of these lymphocytes by radiation has resulted in an immediate alleviation of the symptoms in three cases of encephalitis lethargica.

3 Since the lesions in poliomyelitis and in Landry's paralysis are similar to those of encephalitis, it is suggested that this treatment should be beneficial.

4 The dosage should be very minute since lymphocytes are extremely sensitive to radiation and large doses would produce too rapid absorption of these cells.

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In the first case, because of the presence of a pansinusitis the question of a brain abscess or of a toxic affection of the brain was considered. The cytologic findings of the spinal fluid, however, established the diagnosis of encephalitis. The first x-ray treatment brought about a phenomenal improvement. The cell count of the spinal fluid was also promptly reduced. After several subsequent small doses of x-ray had been administered, the symptoms entirely disappeared. The second case, on account of the predominant mental derangement, was prognosticated as hopeless in one institution. We felt that the increased number of lymphocytes in the spinal fluid warranted the diagnosis of encephalitis lethargica, and, therefore, x-ray therapy was instituted. The results were most gratifying.

In the third case, at the onset there was a spontaneous subarachnoid hemorrhage and symptoms referable to it. At first the possibility of meningitis was considered and antimeningococcic serum was given, but the leukocyte count of 10,400 made this diagnosis improbable. Because of the blood present, the cytology of the spinal fluid could not be determined. As the hemorrhage stopped, the condition of the patient appeared similar to that of the previous cases, that is, restless, drowsy, with severe headache and vomiting. The spinal fluid took on the nature of that found in encephalitis lethargica, *ie*, an increased number of lymphocytes. The number of cells was increasing prior to irradiation and did not fall as rapidly after two applications as in the other cases. This fact, coupled with the initial subarachnoid hemorrhage, suggests a greater virulence. The patient is still under treatment and will require a more extended application of the method.\*

The matter of roentgen dosage was a problem, inasmuch as we were unaware that there had been any previous ex-

perience in the treatment of encephalitis by radiation.

Realizing the marked radiosensitivity of lymphoid tissues and lymphocytes and having noted toxic reactions when these tissues were radiated even moderately, we aimed by small doses to produce salutary effects and avoid any severe reaction which might retard recovery and discredit the method.

The first treatment was, therefore, given as follows: 135 K V, 5 ma, distance 15 inches, filters 4 mm aluminum, time 2 minutes, mechanical single disc rectification. The erythema time had never been computed by a physicist for this apparatus but on a similar one it had been found to be approximately 30 minutes. The estimated dose in r units was, therefore, approximately 40, or one-fifteenth of a skin erythema dose.

Even this minute dose in the first case caused a brief upset the ensuing night, with hallucinations, but the improvement noted on the following day warranted a continuance of the experiment. For economic reasons it was desirable to abbreviate the hospitalization, therefore, another dose was administered 48 hours after the first. The second dose was given with the same technic, adding one minute, *viz*, three minutes, or 60 r. The third dose was again increased by one minute, to 80 r, and after a 48-hour interval. The clinical improvement has already been described in this paper. The day following the third treatment the patient was removed to her home and the radiation continued at the office, where three more doses were applied. The time was increased to five minutes, or 100 r for the fourth and succeeding doses, and the intervals lengthened to 72 hours. After the sixth application there seemed to be no reason for continuing the treatment. The areas radiated were the lateral aspects of the skull, alternating sides, only one side being treated on any one day.

Paradoxical as it may seem and in contravention of the usual concept that heavy roentgen dosage is essential in the treat-

\* This patient has been symptom free since leaving the hospital. Irradiation was given weekly till May 10, 1934. His spinal fluid on May 1 contained 14 lymphocytes per c.mm. He is now working.

demonstrated Such a method is valuable in many cases with thoracic metastases, a primary tumor, pleural malignancy, mediastinal involvement, and to differentiate certain right upper quadrant abdominal lesions

limits of the diaphragm during respiration The difference between the two sides or a

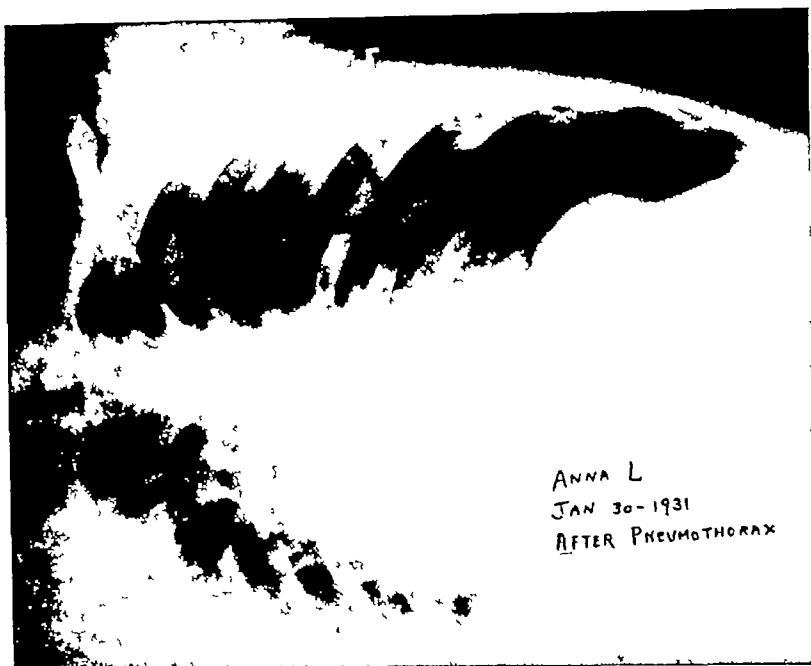


Fig 1 Pneumothorax successfully outlines a tumor of the superior diaphragmatic surface Operation and biopsy demonstrated a lipoma

tases, a primary tumor, pleural malignancy, mediastinal involvement, and to differentiate certain right upper quadrant abdominal lesions

*Bronchography*—This procedure has been so simplified of late that it lends itself to the outlining of the bases of the lungs as a means, at times, of demonstrating the position of the diaphragm (Fig 2) A little cocaine solution sprayed into the posterior pharynx permits dropping of warm opaque oil into the trachea, thus outlining the bronchi The procedure may easily be performed at the bedside

*Respiratory Excursion*—Some patients will be too sick to be transported to the laboratory, in such cases, bedside examination may be used to recognize the diaphragm and the limits of its excursion Two chest exposures are made on one film—at the height of inspiration and a second one at the end of complete expiration, a double image results, with a gap between the elevated and descended

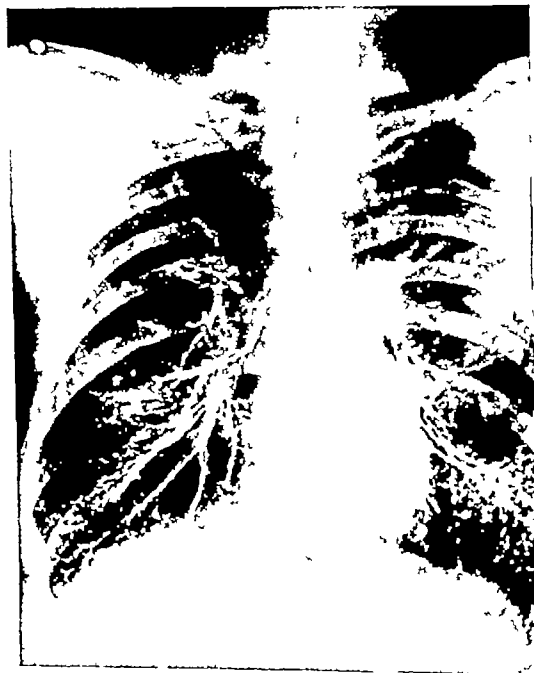


Fig 2 Illustrating how a bronchogram may aid in localizing the diaphragm, especially in pulmonary lesions The technic of bronchography has been standardized of late until it should now have more routine use in obscure cases

# WHERE IS THE DIAPHRAGM?<sup>1</sup>

By WILLIAM H STEWART, M D , and H EARL ILLICK, M D , *New York City*

IN the normal chest the position of the diaphragm is well known and its shadow and mobility are characteristic, but in many disease processes of both thorax and abdomen the diaphragm may be so altered, either temporarily or permanently, that its exact location may be difficult to state. As a matter of medical diagnostic interest and especially if operative measures are deemed necessary, the localization of the diaphragm may become of great importance to the surgeon. This paper comments on some of the roentgenographic findings in diseases of the chest and abdomen in which the position of the diaphragm may be uncertain, and discusses the problem of exact localization by the roentgen ray.

The diaphragm by virtue of its median position between chest and abdomen is of interest to the roentgenologist, not so much because of its intrinsic disease processes as because of its abnormalities, in cases in which there is pathologic involvement of thoracic or abdominal viscera. Abnormal variations in the position, the contour, or the extent of the excursion of the diaphragm may direct attention to a lesion of abdominal or thoracic organs.

The *anatomy* of the diaphragm is well known, as well as its normal roentgen appearance. It is a complete septum between thorax and abdomen only in mammals. Above the diaphragm and in contact with its superior surface, are the lungs, heart, esophagus, and aorta, below it, and in contact with its inferior surface, are the liver, stomach, and spleen. By virtue of its intimate relation with these organs, intrinsic disease of the diaphragm or of any one of these viscera soon results in characteristic roentgen manifestations which call attention to and aid in the detection of the disease process.

The diaphragm is pierced by three openings—for the aorta, the esophagus, and the vena cava. The central portion of the diaphragm is composed of fibrous tissue, the outer margin is muscular. The dome is usually regular and made up of one smooth curve, at times it may present several smaller, shorter curves. There is considerable individual variation in the degree of excursion—from one-half inch on quiet breathing to two inches or more on deep respiration, males more than females. Both sides possess equal mobility. There is variation in the shape and position, accounted for by the habitus. A short, stocky person has a high position and a gentle curve of the dome, while a long, thin individual has a low position and a sharper curve. The left side of the diaphragm may be elevated by "gas" in the stomach or splenic flexure. Normally the right side of the diaphragm is higher than the left.

Roentgen technic takes into account these anatomic considerations and strives to demonstrate the character of the variations and abnormalities concerned with the position, contour, and excursion of the pathologic diaphragm.

## ROENTGENOGRAPHIC AIDS AND TECHNIC

*Pneumothorax* is a simple aid, not used frequently enough when there is a question concerning the exact location of the diaphragm and certain tumors which may be readily outlined by the injection of air into the pleural cavity (Fig 1). In some cases fluid is present, which is first withdrawn, after which air is introduced in as large quantity as possible. Cases with pleural fluid are tolerant to injection of large quantities of air without distress. The resulting hydropneumothorax permits positioning of the patient so that tumor masses and the diaphragm are accurately

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933



Fig 5 An example of localization of the diaphragms by pneumoperitoneum, gas outlining the inferior diaphragmatic surface

#### LATERAL AND DIRECT EXAMINATIONS

Roentgenographic examinations made with the patient in the horizontal position, affected side uppermost, film anterior or posterior, with the x-ray tube opposite, are effectual in demonstrating abscess cavities, with or without fluid level, and in locating the diaphragm (Figs 3 and 4) in patients who are too sick to stand up or otherwise co-operate in obtaining the usual roentgenographic information. A true lateral with the affected side against the film, preferably with the patient erect, will localize the diaphragm in many instances. Pleural adhesions, effusion, and pulmonary consolidations are differentiated by this means. Diaphragmatic detail can often be obtained by using a Bucky diaphragm, with the film rather dense. Also, in effusions the concave curve is more clearly demonstrated and the detail of the base of an involved lung, when hyperaerated, is best obtained with a Bucky film.

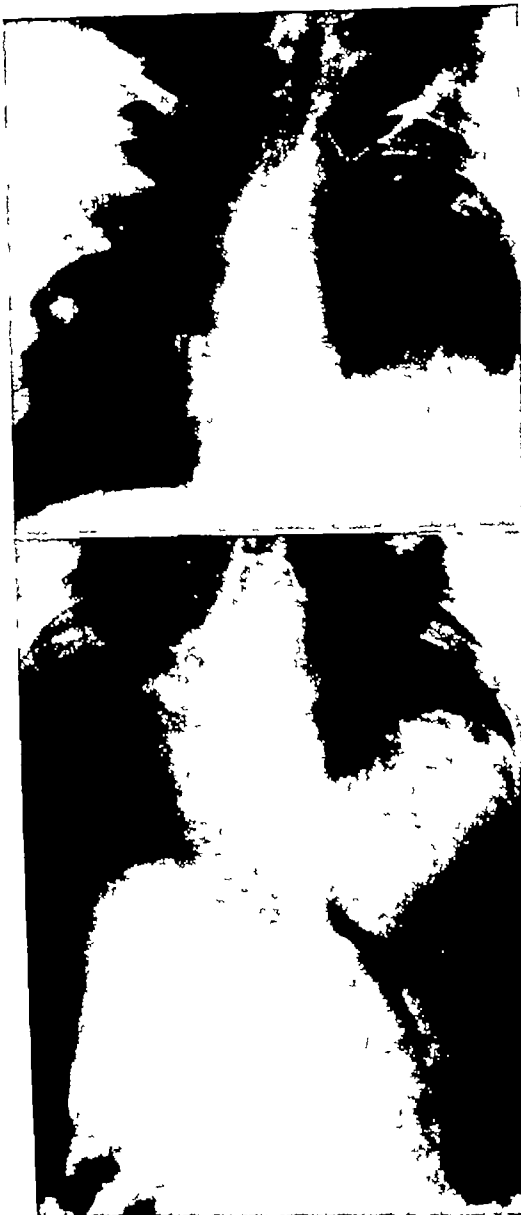


Fig 6-A (above) A rounded, dome-like, smooth, superior border at the base of the right chest, believed to be the left side of the diaphragm. Pulmonary fields clear. Subdiaphragmatic tumor is to be ruled out.

Fig 6-B (below) Pneumoperitoneum localizes the diaphragm. Case was one of huge tuberculous cyst resting on the diaphragm.

#### PNEUMOPERITONEUM

Attacking the problem from below the diaphragm we at once recognize the value of pneumoperitoneum. One of us long ago called attention to the ability of the roentgenologist to demonstrate the subdia-

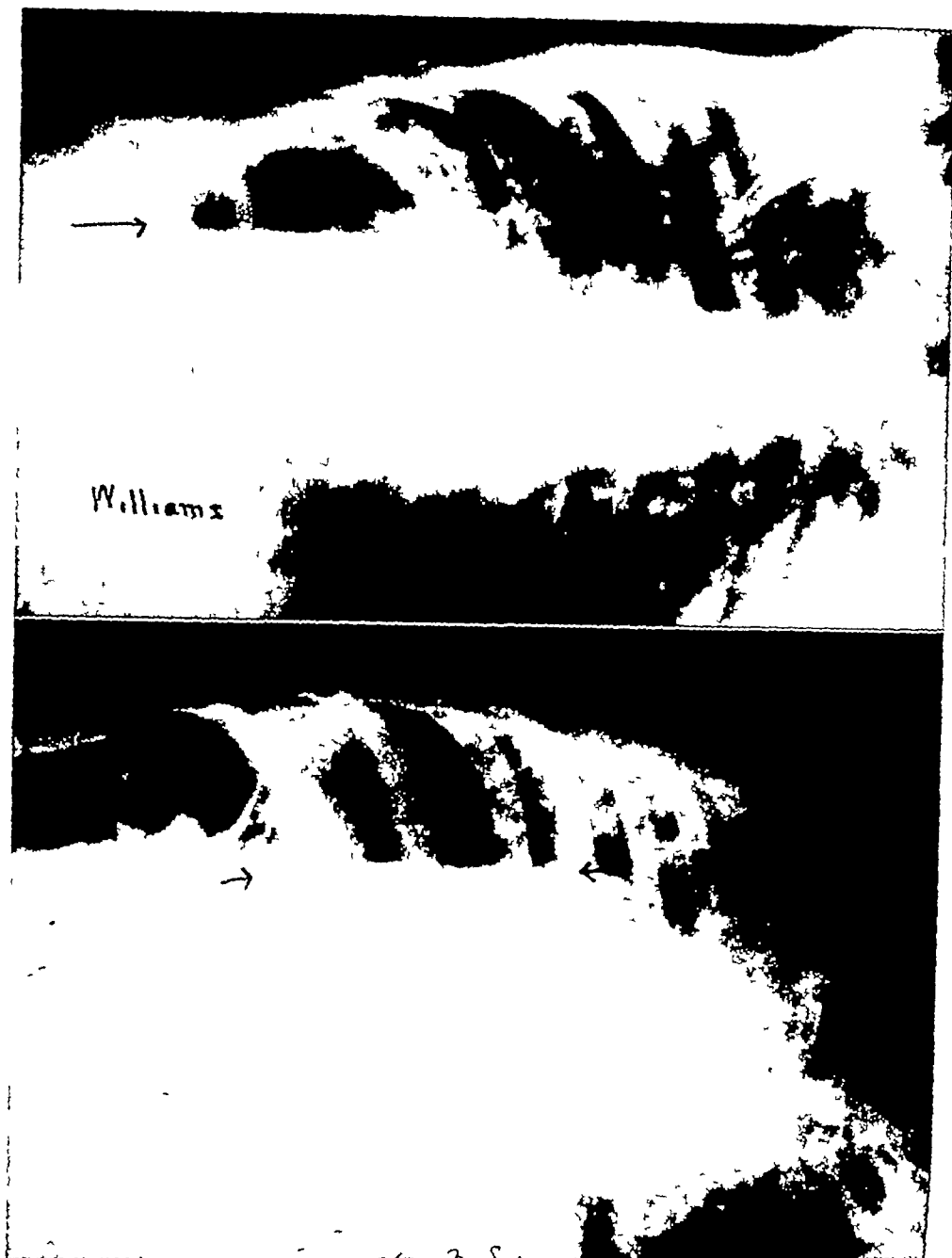


Fig 3 (above) Air above a fluid level on the left side of the body

Where is the diaphragm?

Was a large lung abscess, bronchoscopy demonstrating pus coming from the left lower main bronchus

Fig 4 (below) Air above fluid levels on the left side of the body The lower fluid level (indicated by arrows) is in the stomach, distinguishable by fluoroscopy after barium had been given orally The upper fluid level is in an encapsulated empyema, the diaphragm being localized fluoroscopically between the two

one-sided limitation of excursion can be made a matter of permanent record in this manner for comparison at subsequent examinations

diaphragm will be exceedingly difficult or even impossible mostly impossible on account of the acute illness of the patient or because the surgeon cannot give the roentgenologist time enough to work out the problem as it should be done without jeopardizing the life of the patient After all, this has to be thought of as well as the diagnostic procedure Progressive elevation of what is supposedly the right diaphragm, combined with a history of pain, coughing, and increasing dyspnea, usually

indicates a pulmonary lesion (Figs 7-A and 7-B) Subdiaphragmatic pathology, such as abscess or hepatic suppurations, seldom elevates the diaphragm sufficiently to be mistaken for a lesion within the chest, and the history is not one of a chest disease

The authors cannot close without a word of warning to those men who attempt to make a diagnosis without using all the data available—this means clinical, laboratory, and x-ray findings The history is always most valuable in the differentiation

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Fig 7-A (*above*) Rounded, superior border resembling dome of diaphragm at the right base. Marked limitation of motion.

Fig 7-B (*below*) This patient had progressive elevation of the shadow resembling the dome of the diaphragm, combined with a clinical history of pain, coughing, and increasing dyspnea. At operation a large lymphosarcoma was found *above* the diaphragm, with a rounded upper border accompanied by enlarged mediastinal glands.

phragmatic space (Figs 5, 6-A, and 6-B). Of late years the presence of air or gas under the diaphragm in perforated gastric and duodenal ulcers has shown excellent diaphragmatic localization.

We have been advocating for some time the introduction of a small quantity of oxygen or carbon dioxide into the peritoneal cavity in an endeavor to differentiate the upper liver border from the diaphragm. Only a small quantity of the gas is used and the patient does not suffer from the discomfort of distention. The method may be used at the bedside, the patient not being transported at all, since a bedside x-ray unit suffices to give us roentgenograms for localizing the diaphragm with certainty and demonstrating its exact position. This procedure has limited usefulness in acute or subacute inflammatory lesions as it requires the patient to be placed in an erect position, either sitting or standing.

#### INTRODUCING AIR OR GAS INTO THE STOMACH

The left diaphragm can be localized by the intestinal gas in the stomach, which may be purposely increased by a Seidlitz powder or with an air pump through a stomach tube. In cases in which a fluid level is present on the left side in the region of the diaphragm, barium must be given to differentiate stomach contents. This may seem an uncalled-for suggestion, but we have seen cases in which it was necessary to differentiate the stomach with its fluid contents from a large abscess of the lung in the extreme lower portion of the lower lobe of the left lung. It is of value also in diaphragmatic hernias and eventration, which as a rule occur on the left side.

#### THOROTRAST

Recently thorotrast has been used to better demonstrate the size, shape, position, and changes in the structure of the liver and spleen, thus frequently indirectly locating the diaphragm from below. The authors feel, however, that its use is inadvisable until every other means has been exhausted.

Finally, with all the skill that the roentgenologist can use there will be an occasional case in which the location of the

diaphragm will be exceedingly difficult or even impossible mostly impossible on account of the acute illness of the patient or because the surgeon cannot give the roentgenologist time enough to work out the problem as it should be done without jeopardizing the life of the patient After all, this has to be thought of as well as the diagnostic procedure Progressive elevation of what is supposedly the right diaphragm, combined with a history of pain, coughing, and increasing dyspnea, usually

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# THE INFLUENCE OF ROENTGEN RAYS ON THE GROWTH AND PHOSPHATASE ACTIVITY OF BONE<sup>1</sup>

By WALTER E WILKINS, PH D, and EUGENE M REGEN, M D, *Nashville, Tennessee*

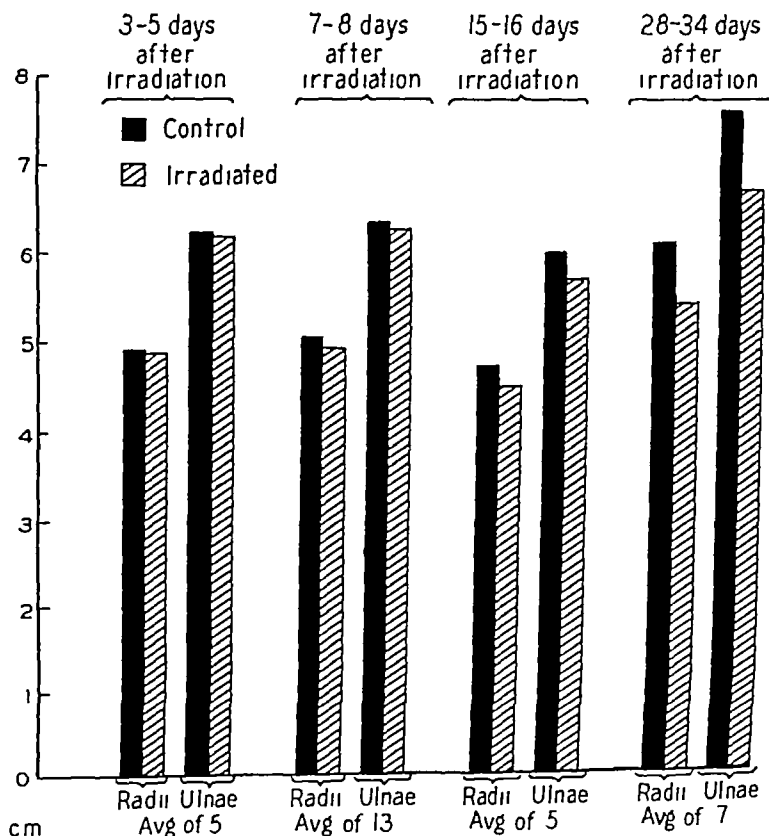
From the Departments of Biochemistry and Surgery, Vanderbilt University School of Medicine

**S**HORTLY after the discovery of the roentgen ray, it was found that exposure of growing bone to this ray is followed by a period of inhibited growth. Brooks and Hillstrom (1) have recently made a study of the amount of irradiation necessary to inhibit growth, the quan-

tity of the effect produced, the duration of the influence, and the coincident histologic changes.

In view of the significance attached by Robison (3, 4, 5) and other workers to the rôle of phosphatase in bone growth, it appeared to us that a simultaneous study of

FIGURE I  
LENGTHS



<sup>1</sup> Part of the expense of this investigation was borne by the Fluid Research Fund  
Accepted for publication April 23 1934

the effect of roentgen rays on growth and on phosphatase activity would be of

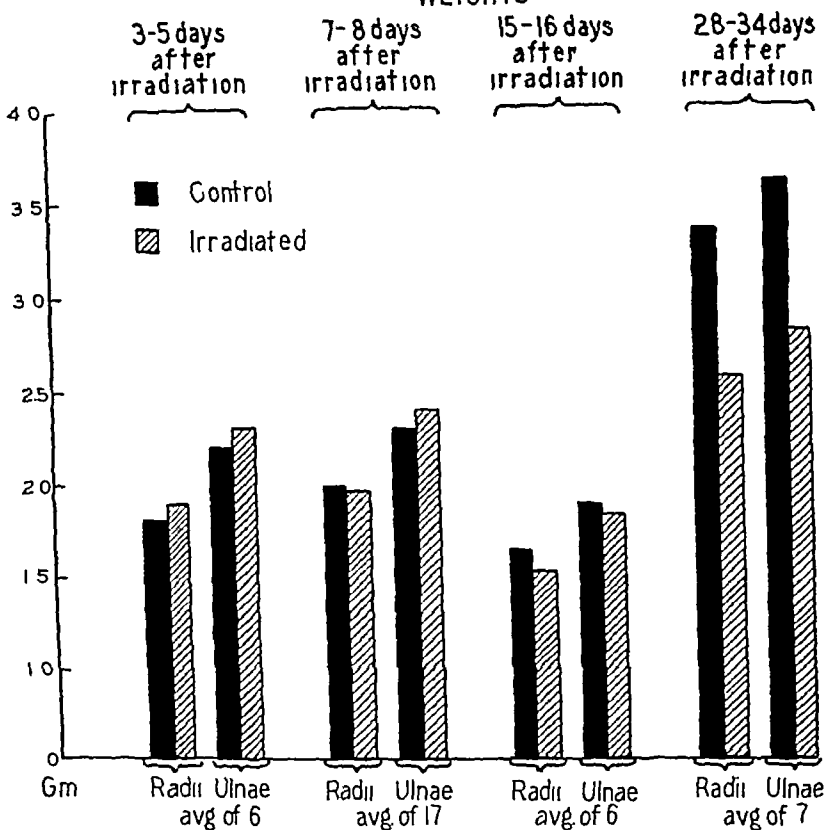
interest The results of such a study are given in this paper

#### PROCEDURE

Pups from 30 to 40 days of age, were exposed to approximately 600 roentgens over the left fore leg, the remainder of the

tissue, including ligaments and periosteum, was carefully dissected away since accurate weight measurements were necessary All bones were treated in as nearly uniform a manner as possible, and were then weighed in suitable weighing bottles on an analytical balance Care was taken to avoid loss of weight by evaporation

FIGURE II  
WEIGHTS



animal's body being carefully protected with sheet lead The factors constituting this dose were from 190 to 200 kilovolts, 20 milliamperes, target-skin distance of 55 centimeters, filter of 0.5 mm copper and 1 mm aluminum, and exposure of 20 minutes The animals were sacrificed at intervals of from three to 34 days after irradiation, the bones from the right fore legs being used as controls The bones of both fore legs were removed, and all soft

The length, including the epiphyses, was measured with a vernier caliper, the entire bone was then cut into small bits and ground in a mortar with No. 40 carborundum This mixture was transferred to an Erlenmeyer flask of suitable size and 25 cc of distilled water added for each gram of bone, the water being used in small portions to thoroughly remove the traces of material adhering to mortar, pestle, and spatula A few drops of chloroform were

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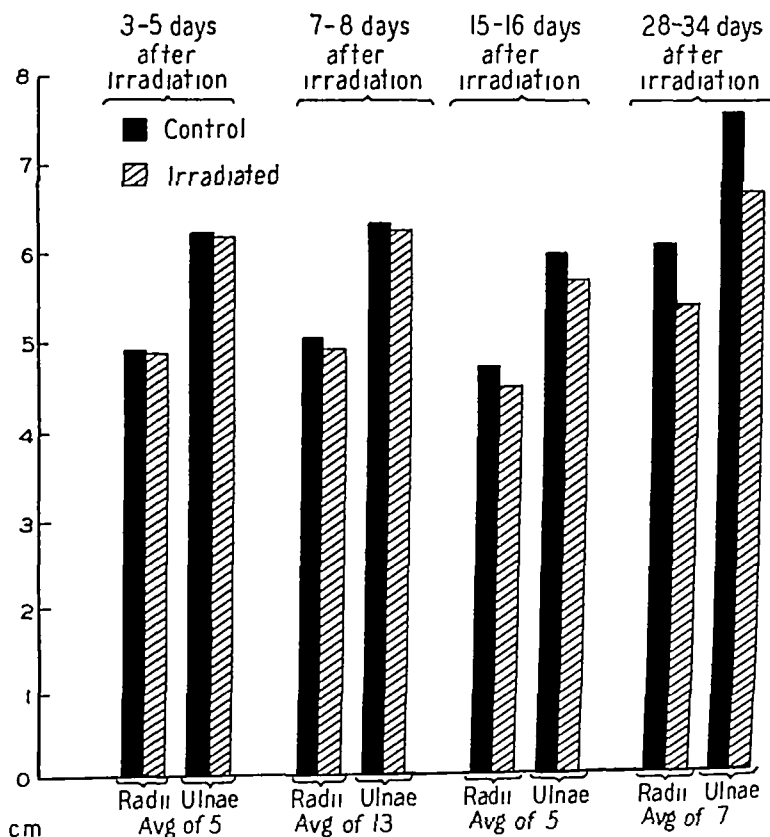
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activated by the roentgen ray, samples of bone extract and blood plasma were exposed to approximately 1,200 roentgens, and determinations of phosphatase activity immediately made on these and samples of the original untreated materials. No differences were detected.

The choice of particular days for sacrificing the animals was arrived at after a number of preliminary studies had been made. It is quite clear that some of the animals, sacrificed within the period of minimal phosphatase activity, may not have been caught at their lowest values. It was originally planned to study these animals over a longer period, but circumstances necessitated our sacrificing a number of them prematurely.

#### SUMMARY

The influence of roentgen rays on the phosphatase activity of bone was studied in a number of pups, which were exposed

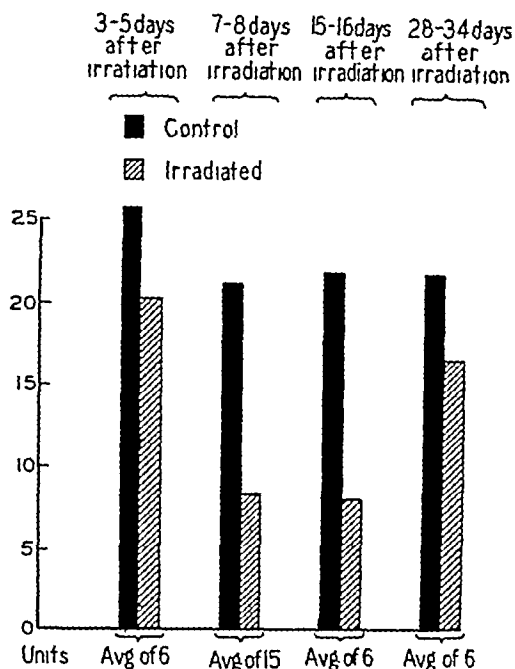
over one fore leg to approximately 600 roentgens. Studies were made on the weight, length, and phosphatase activity of both treated and control bones, over periods up to 34 days. There was a retardation of growth as judged by both weight and length. As compared with the controls, the treated bones showed a decrease in phosphatase activity beginning a few days after exposure, reaching a minimum within from one to three weeks, and showing a tendency toward recovery within from four to five weeks.

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- (4) Idem. The Significance of Phosphoric Esters in Metabolism. New York, 1932.
- (5) Idem. Bone Phosphatase. *Ergebnisse der Enzymforschung*, 1932, I, 280.

added, the flask stoppered, well shaken, and set aside at room temperature for a period of 72 hours, with occasional shaking. At the end of this period, the mixture was filtered through No. 40 Whatman

FIGURE III  
PHOSPHATASE ACTIVITY OF RADII



filter paper. Determinations of phosphatase activity were made on this filtrate, using a technic similar to that described by Jenner and Kay (2) for plasma phosphatase.

In these experiments, 41 animals were used. The ulnae were used for microscopic section of the line of growth at the epiphysis. However, values for weight and length of the ulnae were obtained and are included in the averages given in Figures I and II. The microscopic findings will be reported in a separate paper. Thus all of the data on phosphatase represent values for the radii.

Figure I shows the effect of irradiation on the length of the exposed bones as compared with the controls. Appreciable dif-

ferences were consistently found after from 15 to 34 days. Differences in length are not sufficient criteria for the estimation of growth, and we feel that differences in weight are also significant. The average values for the weights of both irradiated and control bones are given in Figure II. It is quite apparent that there was a greater retardation in growth on the basis of weight than as judged by length, this being obviously due to the fact that the irradiated bones are smaller in diameter as well as shorter in length. It may be noted from Figure II that, during the first few days after irradiation, the treated bones were slightly heavier than the controls. This is not only true for the average values but holds for most of the individual pairs. The cause of this phenomenon is not clear but it is quite possible that analyses of such bones for water, protein, and mineral matter will throw some light on this subject.

The values for phosphatase activity of both irradiated and control bones are given in Figure III. These figures represent milligrams of inorganic phosphorus liberated per hour from a substrate of sodium-beta-glycerol-phosphate by the enzyme in 100 cc of bone extract (containing 4 grams of bone) at a temperature of 38° C., and at a pH of 8.8. The phosphatase activity of the irradiated bones began a progressive decrease within a few days after treatment and reached a minimal value within a period of from one to three weeks. This period of minimal phosphatase activity was followed by a tendency toward recovery. There is some indication that the phosphatase activity of the untreated bones is also affected—this is being investigated.

Two animals have also been studied in an attempt to determine the location in the bone of maximum depression of phosphatase activity, after exposure to the roentgen ray. The bones were divided into epiphyses, metaphyses, and shafts. The greatest depression occurred in the metaphysis, which is the region of greatest phosphatase activity. In order to determine whether or not the enzyme itself is in-

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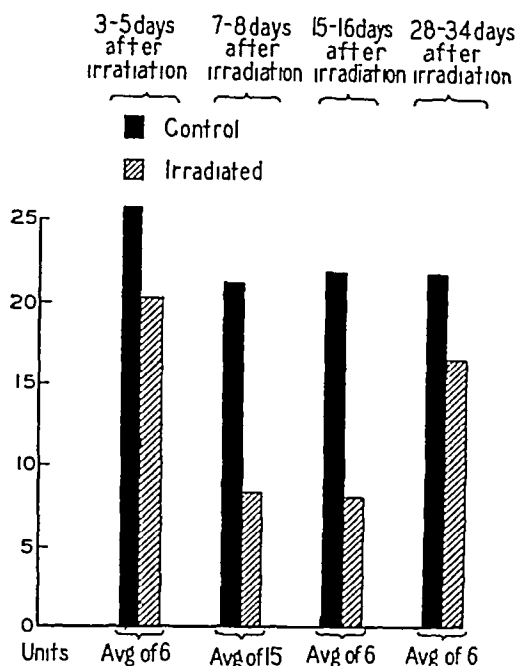
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experience in arteriography has been limited largely to the use of thorium dioxide sol, however, we have found that neopax, skiodan, and diodrast are deficient in radiopacity and produce pain when injected into an artery. The problem of finding an ideal arteriographic medium has not been solved, and further investigations are being carried out.

In the past eighteen months we have used arteriography to examine the peripheral vessels in 85 cases. The following conditions were studied: thrombo-angitis obliterans (3, 4, 5, 7), arteriosclerosis (5), congenital arteriovenous fistula (10), aneurysm of the popliteal artery (6), arthritis, scleroderma, Raynaud's disease, and hypertension. In some cases in which a search was being made for suspected disease normal blood vessels (2) were found (Fig 1). In addition to peripheral arteries, visualization of the cerebral arteries (11, 12), and of the abdominal aorta has been reported (13). Our studies have been limited largely to the upper extremities, chiefly because only small amounts of thorium dioxide sol are required for good visualization. In all instances the procedure was carried out with the patient under local anesthesia and without incising the skin.

In brief, the findings in thrombo-angitis obliterans are "patchiness" of the obliterative process, the three phases of involvement of arteries that depend on the degree of encroachment on the arterial lumens (described elsewhere, 5), extensive collateral circulation, and obliteration of collateral arteries (Fig 2). The characteristics of congenital arteriovenous fistula are increased size and tortuosity of arteries leading to the fistula, "pooling" of the medium in the region of the fistula, and absence of filling of the arteries distal to the fistula. In arteriosclerosis, the rather uniform shaggy outline of arteries the lumens of which are reduced in size is characteristic (5). Data on the arteriographic findings in scleroderma, Raynaud's disease, arthritis, and in hypertension will be reported at a later date.



Fig 2 *Thrombo-angitis Obliterans*—The digital arteries are involved in an irregular, patchy manner. Phases of involvement of the arteries, varying from a simple change in contour to complete occlusion, are revealed. The ulnar artery is occluded at the wrist and a long branch runs distally from above the region of occlusion. The greatly increased collateral circulation is indicated by the fine ramifying twigs.

Opinions concerning the value of arteriography vary from those of enthusiasts, who foresee its use as a routine diagnostic measure, to those of others who express a disregard for it. Our own opinion of the method lies midway between these two extremes. In most cases the procedure is likely to be considered an adjunct rather than an absolute necessity to diagnosis, if experience has been gained in analysis of the symptoms and physical findings of a large number of patients with vascular



# THE VALUE OF ARTERIOGRAPHY

## REPORT OF A CASE<sup>1</sup>

By EDGAR V ALLEN, M D , Division of Medicine, and JOHN D CAMP, M D , Section on Roentgenology, The Mayo Clinic, Rochester, Minnesota

**R**OENTGENOLOGIC visualization of the arteries of living subjects by means of intra-arterial injection of opaque substances is relatively new. According to Edwards, who has reviewed the subject, the procedure was first carried out in 1923. The method has never gained wide use, probably because of the difficulty in securing thoroughly satisfactory mediums for injection. The ideal arteriographic medium is one which has high radiopacity, does not cause pain when injected, is freely miscible with blood, and has no toxic effect on blood, blood vessels, or on other organs or systems of the body. A variety of substances have been used, iodides and bromides of sodium, strontium, potassium and calcium, proteinated silver salts, iodized oil, skiodan, diodrast, neopax, emulsified lipiodol, and thorium dioxide sol (8). Of these, thorium dioxide sol has the greatest opacity and, in our experience, using 8 to 10 c c., has no obvious and immediate injurious effect on the blood, blood vessels, or on the body as a whole. The possibility of latent radioactivity has been widely discussed (1, 8, 9). Unfortunately, however, this property of thorium dioxide sol has not been sufficiently considered in the literature, in relation to the amount of the substance used. In experimental work, from 1 to 5 c c for each kilogram of body weight has been used. In clinical work, for visualization of the liver and spleen, about 1 c c for each kilogram of body weight is necessary. In roentgenologic visualization of arteries and veins of the upper extremities, about 0.10 c c for each kilogram of body weight is sufficient. Ericksen and Rigler, who have made an extensive study of the possibility of harmful radio-active effects

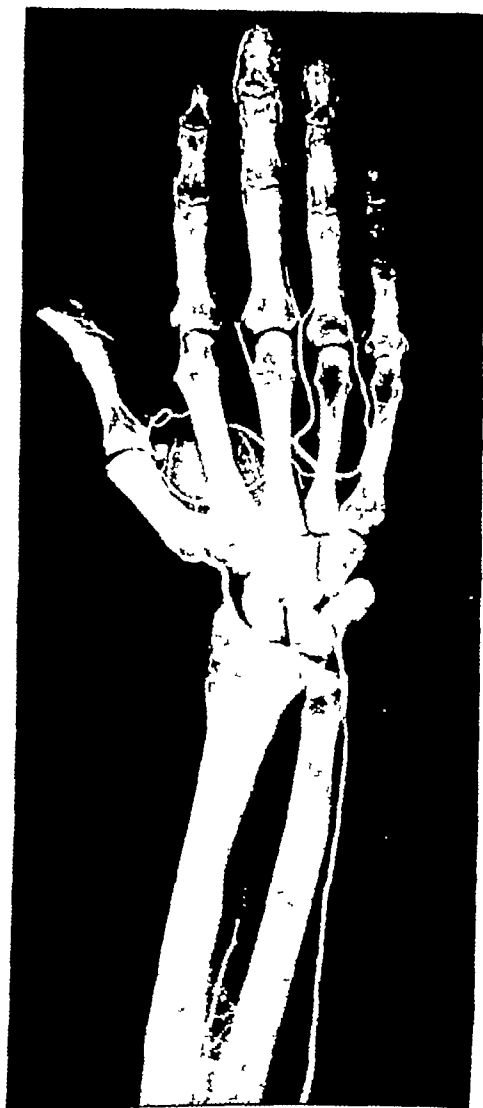


Fig. 1 Normal Arteries—The arteries have smooth contours and their course is direct. There is minimal collateral circulation.

from the use of thorium dioxide sol, consider that even a greater amount than that just mentioned is distinctly harmless. Our

<sup>1</sup> Submitted for publication April 18 1934

minutiæ of arterial disease, information which can be secured in no other way. It is to be expected that the absence or presence of organic arterial disease in Raynaud's disease, and the part played by

lateral arteries and other adjustments to impaired circulation are portrayed in a manner which leaves little to be desired. The mode of progression of the disease and the compensation for it are clearly out-

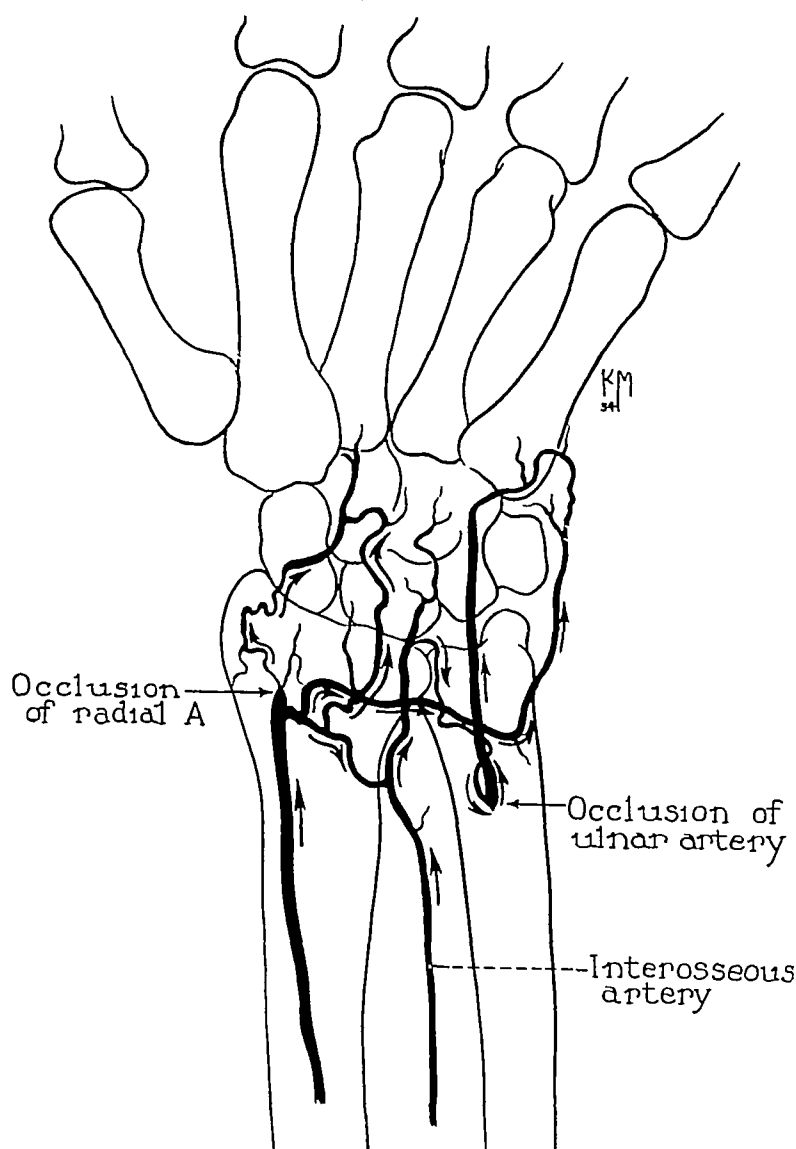


Fig 4 Diagrammatic sketch of part of Figure 3. The probable direction of the current of blood is shown by arrows. Particularly noteworthy is the increased circulation through the interosseous artery from a branch of the radial artery, the maintenance of circulation in the distal part of the ulnar artery by branches from the interosseous and radial arteries, and the long branch of the radial artery which passes to the ulnar side of the wrist.

disturbances in the arterial circulation in scleroderma, can be determined. In thrombo-angitis obliterans, the relation of col-

lined. These observations appear to hold true for thrombo-arteriosclerosis obliterans, although our experience with arteriography

disease, and if calorimetric, pathologic, chemical, and physiologic studies are carried out. The experienced observer is able to reach a correct diagnosis in a high percentage of cases by inference and by

diagnostic procedure which furnished information of unquestionable value. Studies under way at the present time indicate that scleroderma and Raynaud's disease may present fairly constant roentgeno-



Fig 3 Thrombo-angitis obliterans in a case in which diagnosis could not be made clinically. The distal part of the radial and the proximal part of the ulnar artery are occluded. Extensive disease of the arteries of the palm and of those that go to the fingers is present. The interosseous artery extends into the hand and the collateral circulation is greatly increased.

evaluation of the studies mentioned. Arteriography was of no aid in diagnosis in two cases of congenital arteriovenous fistula, but merely served in a confirmatory capacity. It is quite probable, however, that in some cases the method would furnish the only unequivocal information. In only a few cases of thrombo-angitis obliterans was arteriography the single

graphic characteristics. If such proves to be true, the diagnostic value of arteriography in these confusing conditions will be great.

The chief value of arteriography, in our estimation, lies not in the direction of diagnosis but in determining the pathogenesis of the condition. It gives information of inestimable value regarding the

and by numerous small arteries arising from those just mentioned. The circulation through the ulnar artery is maintained by a branch from the interosseous and radial arteries.

The roentgenographic studies in this case indicate not only the diagnostic value of arteriography, but also the powers of compensation for disease which are inherent in the arterial system.

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in this condition has been distinctly limited. In addition, the situation, extent, and nature of aneurysms, arteriovenous fistulas, and arterial emboli can be determined accurately by arteriography. Whether or not the method will add information of value to the knowledge of the pathogenesis of arthritis, hypertension, and of other conditions remains to be learned in the future.

There can be little doubt that arteriography will be used more extensively. It is not too optimistic to hope that roentgenologic visualization of the arteries of the living subject will enhance information about the circulation in much the same way that roentgenography has increased knowledge of the digestive and urinary systems.

#### REPORT OF A CASE

A Greek laborer, aged 35 years, who had smoked on the average of twenty cigarettes a day for twenty-three years, was examined at the Mayo Clinic in February, 1934. Seven months previously the fingers of his left hand had been injured when they had been caught between the door and the jamb of a box car. The nail of the fourth finger had been loosened from its bed and the third finger had been severely bruised. Pain had occurred immediately and had persisted up to the time of admission. Tincture of iodine had been applied to the fingers and the hand had been bandaged. About three months later, treatments had been begun in which and ice pack had been applied to the hand for thirty minutes, three times daily, these had continued for four weeks. During this time the distal half of the third finger had turned black and had become swollen. The patient disclaimed symptoms of phlebitis and of trouble in the lower extremities.

At the time of our examination the distal half of the third finger was gangrenous, the third and fourth fingers were slightly swollen, and pulsations were absent bilaterally in the ulnar, dorsalis pedis, and posterior tibial arteries and diminished in

the left radial artery. There was moderate abnormal pallor of both feet and of the fingers of the left hand, on elevation, and moderate abnormal rubor, on dependency.

An arteriographic study of the left fore arm and hand was made. The resulting films revealed complete occlusion of the radial artery, distal to about the lower end of the radius, and occlusion of the ulnar artery, proximal to a point 3 cm above the distal end of the ulna (Fig 3 and 4). The interosseous artery extended into the hand, and the palmar arches and digital arteries were extensively diseased.

#### COMMENT

The problem in this case was to determine whether trauma alone was responsible for the patient's condition or whether there was some primary disease of the arteries. As a result of experience in other instances, the assumption that a chronic occlusive disease of the arteries had existed before the trauma was entirely reasonable. This assumption was strengthened by evidence of chronic occlusive disease of the arteries of the lower extremities. However, conclusive evidence was lacking, hence, arteriography was performed. On the basis of the findings from this procedure a diagnosis of thrombo-angitis obliterans was made.

The remarkable compensation for occlusion of the chief arteries is clearly shown in the roentgenogram. In spite of the fact that the distal portion of the radial artery and the proximal part of the ulnar artery are completely occluded, the circulation to the hand and to the fingers, exclusive of the third finger, is adequate to maintain normal function. This physiologic compensation is effected by projection of the interosseous artery into the hand (beyond normal limits), by branching from the radial artery at the point of occlusion, by a large branch arising from the radial artery just proximal to the point of occlusion, by a cross-branch connecting the interosseous artery and the uninvolved portion of the ulnar artery,



Fig 1 Hemangioma of forearm R M C., 8 months of age, whose forearm became red two weeks after birth. Five weeks later the arm began to swell, one month before coming under observation it began to ulcerate. This case represents a rather common type of complication. (For other cases see References 3 and 4.)



Fig 2 Same case as shown in Figure 1. Arm presents the usual scarring seen in those cases accompanied by spontaneous ulceration. Due care must be given all cases of angiomas treated by any measure, otherwise the operation will be blamed for this rather frequent complication. A number of radium treatments were given over appropriate areas while the ulceration was in progress.

#### MALIGNANT CHANGE IN NEVI

There is a well-grounded idea existing among the public that to treat a nevus is to invite malignancy, yet, on the other hand, it is a well-established fact that many cases of malignancy start from nevi. Unfortunately, even with the publicity that has been given to this subject, there still remains, among a certain class, constant fear that it is dangerous to remove nevi.

In this series, only three cases were observed in which there was malignant degeneration. This by no means gives the correct ratio, as it is not unusual, while taking the history of an epithelioma, to have the patient state that it began from a small spot or mole. Two of these three cases had large pigmented moles in which the breaking-down process had just started. One was upon the forehead and the other upon the back, and both promptly yielded to treatment with radium. They were included in this list because they were referred for treatment under the above head. The third case was a girl, six years of age, who had a large hemangioma of the face extending over the right and left cheek, involving the upper lip and nose. The front teeth and premaxillary bones were enlarged, causing the upper teeth to project well beyond the lower jaw. She was treated with radium for some time, with no result except scarring. About five years later

she was again seen. During that time she had developed an ulcer upon the face, upon which various procedures had been tried—excision, skin grafting, and various forms of cautery. Healing was only temporary, and finally it developed into a rodent ulcer. The nose and upper jaw became involved, terminating in death at the age of fourteen. It would be interesting in this case to know just what influence the irradiation had upon the termination.

#### SPONTANEOUS ULCERATION

A number of cases, mostly cavernous hemangiomas, have come to notice with extensive ulceration from no assignable cause, while another group was attributed to a trifling injury. Reference has been made to cases in which the ulceration brought about a cure, but such a fortunate ending was not observed in any case of this group. The place where the ulceration occurred was usually marked by scarring that was not seen in those cases of similar size that had been reduced by irradiation, and the amount of disfigurement was much less than would be expected from the appearance of the ulcer. In several of these cases of spontaneous ulceration, the conditions for a time were quite alarming. An area would become gangrenous and extend in various directions without any particular reason, or, strangely enough, it might begin in several

# THE TREATMENT OF NEVI A REVIEW OF CASES TREATED DURING THE LAST FIFTEEN YEARS, WITH ANALYSIS OF END-RESULTS<sup>1</sup>

By WILLIAM S. NEWCOMET, M.D., *Philadelphia*

THE results obtained from the use of radium in some cases of hemangiomas are all that may be desired. Instances have been seen in which large tumor masses have entirely disappeared without any sign of scarring, and the overlying skin was absolutely perfect.

Many cases come under observation in which some surgical procedure has been employed, followed by recurrence of the mass and large scars, which make them more difficult to treat. Frequently, the blood vessels have enlarged beyond the previously involved area, giving a crater-like shape to the tumor, while in others, especially those cases in which carbon dioxide snow has been employed, large ulcers are seen. It would seem logical, therefore, that some mild irradiation should first be used and, if it fails, then resort to surgery. The method for the eradication of these troubles depends largely upon the following factors: (1) condition of the nevus when seen by the physician, (2) the previous history, (3) the histologic formation of the mass.

For convenience in treatment, a purely arbitrary division has been adopted in this review of 506 cases of nevi, as follows: (1) hemangiomas, with subdivisions of different grades into capillary and cavernous, which comprised the largest, and totaled 422 cases, (2) lymphangiomas, which numbered 14 cases, (3) fibroangiomas, including the various forms of moles, which amounted to 70 cases.

The difference between the rather large first group of hemangiomas and the small third group, including moles, is explained by the fact that, as a rule, when moles first appear upon the body they are small and are seldom brought to the attention

of a physician until they become troublesome or large enough to cause disfigurement. If all cases of moles were recorded, the proportion in this review would no doubt be entirely different.

The type of nevus most susceptible to irradiation is the cavernous hemangioma. Its history is quite distinct and differs from the others in that at birth, or shortly afterwards, a small spot is noticed which enlarges rapidly (within a few days, weeks, or sometimes a few months), then becomes stationary or may still continue to enlarge slowly. The history of the capillary type is not so distinct and there is some element of doubt as to its formation. Although many individuals will contend that nothing was seen at birth, a few days later the discoloration will be noted but, as time progresses, very little difference in its size and character will develop. The fact that these marks are flat and of no distinct tumor formation, naturally makes detection at birth rather difficult, due to the incidental discoloration of the child's skin. Moles are usually observed at birth, and show little change as time advances, and to some extent this is true of lymphangiomas.

All three of the above-mentioned classes may remain stationary for years and then, for some unknown cause, enlarge rapidly. Cases have been known in which a small spot of one or two millimeters will enlarge within a month to a centimeter or more. At times this growth is associated with some trifling injury. In the adult, this is practically the only type that comes before us for medical treatment. A histologic study of all the different forms of nevi would prove interesting but it would be impossible to obtain enough tissue sections to make comparisons of the various types.

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933.



Fig 1 Hemangioma of forearm R M C, 8 months of age, whose forearm became red two weeks after birth. Five weeks later the arm began to swell, one month before coming under observation it began to ulcerate. This case represents a rather common type of complication. (For other cases see References 3 and 4.)



Fig 2 Same case as shown in Figure 1. Arm presents the usual scarring seen in those cases accompanied by spontaneous ulceration. Due care must be given all cases of angiomas treated by any measure, otherwise the operation will be blamed for this rather frequent complication. A number of radium treatments were given over appropriate areas while the ulceration was in progress.

### MALIGNANT CHANGE IN NEVI

There is a well-grounded idea existing among the public that to treat a nevus is to invite malignancy, yet, on the other hand, it is a well-established fact that many cases of malignancy start from nevi. Unfortunately, even with the publicity that has been given to this subject, there still remains, among a certain class, constant fear that it is dangerous to remove nevi.

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other areas independent of the original site. The gangrenous condition is similar in its general appearance to those cases of moist gangrene and, while it may be due to some infection, the direct cause

extent, it explains the disappearance of masses of considerable size, in cases in which only an extremely weak application has been given. As a general rule, in cases in which the vessels are covered



Fig 3 Hemangioma of head. M. U. R., 11 months of age. Photograph taken Dec 16, 1926. When the patient was two months old the hemangioma was the size of a quarter, gradually increasing until it attained its present size (4 cm. in diameter, 2 cm. in height).



Fig 4 Same case as shown in Figure 3. Treatment by 100 mg. radium, given in two positions, 2 hours each, elevated at 2 centimeters. Seven applications were given between Feb 10, 1927, and Jan 24, 1928. Note the growth of hair over involved area.

would appear to be a clot choking the circulation in the vessels. Naturally the general symptoms are proportional to the involved area. Spontaneous ulceration is more than a passing interest, and should lead to serious thought in cases in which treatment of these tumor masses by irradiation is to be considered.

It would be natural to suppose that the trauma, from the irradiation, would be sufficient to cause a reaction similar to that seen in ulcerative cases. While there have been a number of cases in which the reaction was much more intense than was desired, it has never had the character of that seen in the spontaneous cases, nor was the scar the same. From excessive reaction, the scar has a scaly appearance for some time, even several years, while the scar in the spontaneous cases is usually hard and firm, with some tendency toward the formation of keloid.

The element of dosage cannot at all times be correctly estimated and to some

with a good layer of skin, the result will be better and there will be less danger of ulceration than in those cases in which the large vessels are practically exposed, with very little true skin for their protection. It will usually be observed that in cases in which the mass is composed of spongy vessels, the amount of irradiation needed is small, as they yield easily, but if the mass is more or less fibrous, the resistance is greater. This factor also explains the difficulty in treatment of the "port wine stain." The vessels are small, under these circumstances they show a stronger resistance, and the relation to the surrounding tissues is greater. At the same time, this fact must be coupled with the difficulty of obtaining an even reaction over the involved area.

#### DISTRIBUTION

The distribution of these marks is interesting and, while many are complicated by having several areas involved,

only those were noted which were of sufficient size to warrant attention

Abdomen	4
Arm	26
Arms, etc	6
Back	19
Body	8
Chest and shoulder	14
Face	303
Face, etc	8
Face, neck	4
Hand	14
Head	27
Legs	20
Mouth	7
Neck	20
Penis	1
Tongue	16
Tongue and mouth	3
General	6
Total	506

By examining this list one is forced to observe that by far a greater number of these marks were upon the exposed parts of the body, 303 of the 506 being upon the face. The argument is often advanced that personal appearance enters largely into consideration. Most of these cases, however, were small children brought for treatment more in alarm of serious consequences than concern about the defect itself. In the adult, personal appearance may be a factor, since in this list 349 were females while only 157 were males. We find also, as a rule, that marks upon the covered parts of the body are not neglected, and the men who have reached maturity are as persistent in their treatment as the women.

A number of hemangiomas have been observed about the female genitalia, but only one in a male. It was a small tumor mass 15 by 10 mm in diameter, elevated 6 mm, and situated on the upper surface of the glans. It was fairly resistant to the direct method of treatment.

Nevi are unusual in the colored race. In this group only one case was seen, a girl seven years of age, who was sent in as a case of lymphangioma. The mass had been removed by operation but promptly recurred. At the time of observation there was a tumor on the face directly above the angle of the jaw, about 3 by 4 cm in diameter, elevated 1.5 cm,

and composed of three rather distinct nodules. It was given three mild applications of radium, with no effect. Irradiation was not pushed, for the reason, as is well known, that the after-effects upon the skin of the colored race, due to the loss of pigment, are often more displeasing than the original trouble. A number of years later this girl again came under observation. The mass was still practically of the same size, but a biopsy, studied by another pathologist, pronounced it a fibro-angioma. Therefore, if it were either a fibro-angioma or a lymphangioma, considerable irradiation would be required and the probable end-result would not justify such a procedure.

#### TREATMENT

The treatment of these cases depends largely upon the history of development and the character of the nevi. As most of them appear upon the exposed surfaces of the body, a good cosmetic result is usually desired. In some of the cases of cavernous hemangioma, it is possible to have the mass entirely disappear with absolutely no trace of any change in the overlying skin, but in cases in which there has been widespread displacement of the skin elements by the enlarged blood vessels, or a decided increase in the fibrous elements, some scarring is to be expected. This scarring at times is best corrected by some surgical procedure. The question might be advanced: "Why irradiate in the beginning if some surgical procedure is necessary in the end?" The reason is that many of these masses will extend about the periphery if not irritated before an operation. Furthermore, if the mass is removed by irradiation, the field of operation is smaller. Some surgeons will contend that it is difficult to remove the scar from the irradiated part. On the other hand, it must be admitted that the bleeding which is usually present during the removal of these masses, is greatly reduced by irradiation. This factor alone should be considered. It seems justifiable,

then, to adopt the rule that, in all cases, irradiation should first be tried

Generally, the more time taken in the treatment of these cases the better will be the result, particularly in younger children

In contrast to the deformity due to atrophy, the return to normalcy of the part, by removal of the offending mass may be mentioned. This was well exemplified by the removal of a large caver-



Fig 5 Hemangioma of the lip W S, 5 years of age, in whose case hemangioma was first noticed when the patient was 8 months old, gradually increasing in size until it was 3 cm long and 2 cm wide. The teeth were displaced inward



Fig 6 Same case as shown in Figure 5. Result from application of four radium needles of 12.5 mg each monel metal, inserted into mass for 4 hours. One month later a 50 mg local application was given for 20 minutes, filtered by 0.3 mm silver. Note that the permanent teeth are in line

In cases in which intense irradiation is necessary, due care must be given to the fact that the treatment will not only inhibit the mass, but also the growth of the surrounding tissues, as growing tissues are highly susceptible to irradiation. While the results may not be apparent at the time or immediately after the treatment, when the child matures a decided lack of development in adjacent tissues will be noticeable. In certain instances this atrophy cannot be avoided and under ordinary circumstances will not be noted, but some cases in which the defect has caused considerable distress have been brought to our attention. One particular case, when seen years after treatment of the tongue, showed that organ to be only about half its natural size and could not be projected beyond the line of the teeth.

Because of the susceptibility of the surrounding parts, nevi should always be irradiated with radium, and not with roentgen rays. It is evident that it is easier to confine the effects of radium to a limited area

nous hemangioma involving the mouth on the right side and pressing the temporary teeth inward. The permanent teeth are now in perfect line, symmetrical, and perfectly sound, with no distortion of the soft parts.

A number of large hemangiomas occurring in the scalp have been treated with remarkably good results. They ranged in size from 2 to 4 cm in diameter, were usually regular in outline, and were elevated from 0.5 to 1 cm, with little or no hair on them. Under such circumstances, a bald spot of the same dimensions would naturally be expected to follow treatment because of the displacement of the skin elements by the tumor, and the effects of the irradiation. With the exception of those patients who had had either surgical operations, caustics, or CO<sub>2</sub>, in all of the cases with hemangioma of the scalp, a year after treatment, the affected area could scarcely be found, hair having almost completely covered the site of the former mass. As a rule, these tumors upon the head are highly susceptible to

irradiation and can be easily treated by the cross-fire method

In contrast to hemangiomas occurring upon the head are those upon the hands, where they appear to be unusually resis-

ber of cases have been seen to support this fact. This is particularly well emphasized by the case of a young girl who had a faint pigmentation of the skin of the left arm, from the hand to the shoulder,



Fig 7 Hemangioma of foot. Notice the scar, resulting from operation. The mass, as frequently observed, is larger



Fig 8 Fibrohemangioma of lip D M, 14 years of age, had had two operations performed upon the upper lip. Note recurrence of the growth—there is also a loss of sensation and muscular power

tant and likely to be injured during the course of treatment. Infection of the area of radium reaction will result in a rather severe scarring. Extensive surface involvements, with fine open network of either flat or slightly raised vascular areas, irregular in outline and interwoven with areas of normal skin, so often seen upon the arms or legs, are usually hard to treat. If they show no sign of extension, the use of the electric needle will give fair results. On the other hand, if there is a tendency toward growth, irradiation should be employed to obtain the best results.

Aside from these large cavernous hemangiomas that at times produce large tumor masses and yet yield easily to irradiation, are those which on the surface appear only as "port wine stains." The fine dilatation of the vessels would appear to be on the surface only, and, it has been pointed out, if the skin can be bleached by slight pressure, the superficial character of the lesion is confirmed. This is not always true, however, and vessels extend deeper than is usually supposed. A num-

ber of cases have been seen to support this fact. This is particularly well emphasized by the case of a young girl who had a faint pigmentation of the skin of the left arm, from the hand to the shoulder, the left breast, and chest wall. The left breast was decidedly larger than the right, and a roentgenogram of the bones of the arm and hand showed that those in the left side were larger than those in the right. The skin over the involved area was a faint red and could be easily bleached by pressure. In this case nothing was to be gained by any form of treatment. Attention is called to the fact that in these extensive capillary hemangiomas the process is widespread and scattered through the different tissues with more or less uniformity, while in the cavernous type, the tumor mass may be extensive yet the dilated vascular area may remain distinct without appearing to be an integral part of the other tissues.

#### COMPLICATIONS

At times, unforeseen complications will arise, but while the employment of radium has little to do with either the cause or result, its use invariably incurs a certain amount of censure. In one instance a young girl developed measles. The nevus had been mildly treated, but the inflamma-

tory condition of the skin caused some ulceration, with considerable infection of the surrounding tissue. After recovery, the nevus appeared to show very little change, yet her parents refused further treatment. Several cases became infected with impetigo contagiosa, which gave rise to some anxiety until the diagnosis was established.

When extensive areas are treated in children, especially the very young, they will often develop a toxic condition, with a more or less general systemic reaction and fever of a mild type. This is accompanied with eruptions upon the skin, usually a number of furuncles. In others, patches of eczema will appear not confined to the local area, but scattered over the body. This complication has been observed in a number of instances, when the local area otherwise showed no sign of reaction. The symptoms, as a rule, are not alarming, and usually subside in a week or ten days. The condition of the child's general health does not seem to influence the severity of the symptoms. Well-nourished children often appear to be more affected by this reaction than those who are undernourished. It is evidently due to absorption of products produced by the disintegration of the cells in the nevus. One case in which this reaction was unusually severe, was that of a small girl, with a large mass extending from the line of the jaw on the left side of the neck to the shoulder and down into the chest along the anterior wall. The skin covering the area was perfect. Several times, when the applications were made, it was supposed that the patient suffered from pneumonia. The mass in the neck promptly disappeared, but because of the severe reaction and the possibility of deep tissue changes, it was decided not to treat the chest. Outwardly the result was perfect, but the roentgenogram still showed a rather extensive shadow in the left chest.

In the smaller nevi, in which the reaction produces a mild degree of erythema, often attended by a slight burning or itch-

ing sensation, it is well to keep the parts protected, as scratching or rubbing may lead to abrasions and consequent infection. To obtain a satisfactory result, ulceration should be avoided, if possible.

Injury to the affected part during the stage of reaction usually produces more scarring. One unfortunate case was that of a small boy with a large hairy mole upon the right cheek. During the time he was undergoing treatment, his clothing accidentally became ignited, causing a burn upon the shoulder and neck to the upper edge of the mark on the cheek. There was some contraction of the whole scar but the general disfigurement was less than might be expected, considering the size of the area involved. While the burn from the fire might have included the mark, happily it stopped at the upper edge of the area under treatment.

#### TECHNIC

To give any routine technic for the treatment of nevi in general would be quite impossible since each case must be treated individually. The size, depth, and particularly the structure of the tumor must be fully considered in conjunction with the variation and susceptibility of the skin to irradiation. Children require especial attention in this regard, and it has been our procedure to give a small initial dose, increasing it as the treatment proceeds. Six weeks or two months should elapse between treatments except when a rapid distention of the mass occurs. It has not been our practice to give small repeated doses at frequent intervals, a method which seems dangerous. If the initial dosage is hard to calculate, how much more difficult it would be to determine the amount retained at each application when given in rapid succession.

The apparatus used must be capable of wide variation, and all forms of radium applicators will prove useful. The plaques, tubes, needles, and seeds may be fashioned into various shapes in order to give an even amount of irradiation to the whole mass at the same time. It is this

evenness of application that produces the smooth result. When radium is applied unevenly and areas are omitted, it will be found extremely difficult, with further treatment, to balance the edges with other parts.

Under ordinary circumstances, the greater number of these cases were treated by the direct or cross-fire method, calculating a dosage so as to give about two-thirds of an erythema to the deeper layers. In small marks, with about a millimeter elevation, the radium has been applied directly to the surface by a plaque or tubes evenly distributed over the area. Usually about 0.2 mm of lead, or its equivalent, was used to filter out the low rays. The high beta rays have been employed, as they materially cut down the time of application, and the results seem to equal those secured in cases in which the filter has been one, two, or three millimeters of lead. The error in this method is that, the farther the radium is raised, the greater will be the depth dose, and that certainly is not desired.

In those cases in which there is a considerable tumor mass, the cross-fire method is usually employed, calculating the dosage so as to give its maximum in the deeper layers with as little effect upon the overlying structure as is consistent. When this cannot be effected or when the tissues are resistant to radiation, and the overlying skin is in danger of destruction, it is best to implant the radium. When this method was employed in this series, the ordinary monel needle was used, with no untoward results that could be ascribed to the choice of filter.

While gold seeds may be employed in cases in which interstitial treatment is desired, it seems unnecessary to leave some foreign body in a mass of this character. Small radon seeds (gold) are valuable in cases in which minor areas are to be treated in parts, and shields of various forms cannot be properly placed. In such cases it should be remembered that the time of application must be very short for the reaction is usually intense.

In concluding these remarks upon tech-



Fig. 9 Hemangioma of neck and chest. M. McC., 2 months of age. A mass upon the neck was treated with 100 mg. radium, nine positions, 1 hour each, filtered by 1 mm. lead and 7 mm. wood. The first application was in May, second in September, no local reaction. The mass in the neck disappeared. Symptoms of a bronchopneumonia developed after each application, and treatment of chest was not deemed advisable.

nique we would not stress the adoption of any one method. The cardinal rule for all treatment should be to avoid an excessive amount of irradiation. The application may be repeated if not sufficient but an excessive amount of irradiation cannot be recalled and no antidote can be given. Often the effects of severe treatments are most difficult to repair and will produce an objectionable cicatrix.

#### COMMENT

The tabulation of results would be most desirable. This, however, is more or less impossible, except when the individual case can be considered. In one instance, there may be a large, most disfiguring mass, and a pleasing result cannot be expected. Yet, with the application of a minimum amount of radium, the mass yields and the overlying skin is left perfect, with the affected part appearing normal. Again, a mass perhaps only half the size of the former will shrink and leave

a surface of scar tissue devoid of color and the natural skin elements, including the fine hairs, all of which are so essential to the natural tone of the involved area

In those cases in which the trouble occurs

of the lesion so as not to extend to the deeper structures. In two cases the angioma was upon the upper lid and in both cases there was no reaction upon the under surface—when the marks disappeared the



Fig 10 D P, 20 months of age, had a tumor,  $3 \times 2 \times 1$  cm, upon the upper lip, which was treated by 50 mg 45 minutes direct contact. Six applications were given between February and May



Fig 11 Same case as shown in Figure 10, the patient now being 5 years of age. The photograph shows the condition three years after treatment

upon the face about the eyes, special attention is required and a thorough examination should be made before treatment. The enlarged vessels often involve the eye and, when the mass shrinks, exposing the eye, it will be found to be imperfect. If attention to such a condition has not been given previous to the application, it is liable to reflect discredit upon the radium treatment.

To a lesser extent, this is also true of the cases involving the nose and throat.

It is possible, in most instances, to prognosticate the result, and this should be done, especially in those cases in which a perfect result is not expected. Circumstances alter cases to such an extent that a method of treatment meeting all requirements in one condition may be discarded in another seemingly similar one. It is well to present the facts to the patient or his family and prevent disappointment. Always bear in mind that, while these marks may be objectionable, the scar left by their removal may be more so, and in the few cases in which there is no chance to afford relief, treatment should not be undertaken.

A number of small marks close to the eye and upon the eyelid have been treated. The dosage in these cases has been calculated according to the superficial character

skin was normal. If the tumor mass extends through the eyebrows or lashes, the area has to be left untreated, as these are highly susceptible to irradiation. In children in whom the hair is undeveloped, it is impossible to get a correct balance.

There were certain groups in which the results were unusually brilliant. In one group of 12, the end of the nose was involved, giving a most grotesque appearance. The enlargement in several was about the size of a cherry and much that color, while in others it was covered with normal skin. The unusual results in these cases may be due to the fact that the end of the nose can more easily receive the cross-fire treatment from a number of angles. Several of these patients are now adults, exhibiting no sign whatever of previous trouble either in form or skin texture.

A number of other cases have been treated in which the mass was at the bridge or the base of the nose, and, while the results were favorable, they did not compare with the former class. If the tumor mass was at the angle of the jaw, due regard was given to the underlying salivary gland, making it difficult to reach the deeper parts of the tumor. Here again, the results were not so uniform.

as were those upon the nose, mouth, or scalp

In two cases in which the leg was affected with large spongy veins passing from the thigh to the ankle, prolonged treatment proved useless. One case was complicated, with large ulcers about the ankle. These two cases might be compared with the extensive "port wine stain," previously mentioned, in which treatment was not attempted because of the general enlargement of the involved parts

#### SUMMARY

In this article the effort has been made to review a large number of cases and group them, in order to show that the results obtained were not temporary, and, as time passed, that no sequelæ followed to mar them. In only a few instances, in which the attempt was made to relieve some unusually distressing case by irradiation, was it necessary to resort to any surgical procedure. Several cases, treated a decade or more ago, have now reached adult life and show some slight deformity of the affected part, due either to the lack of development or to the fact that some of the natural tissues were displaced by the mass. It must be remembered, however, that the younger the child is when treated, the greater will be the possibility of this atrophy, or lack of develop-

ment. In the majority of cases, results of treatment were very satisfactory. The marks or tumor masses had disappeared, and the sites were practically normal and without scar. No other method could accomplish so much and, while the treatment is not so rapid as in other treatments, the results are better.

These lesions are not dangerous to life, therefore, there is no justification for the employment of any dangerous procedure.

In conclusion the fact is stressed that in all cases the mild application of radium may bring about a diminution of the tumor mass and it should always be used previous to operation. Even in severe cases the reduction of the tumor mass will materially reduce the operative risk.

These deductions have been made from previous publications upon this subject, time now having permitted them to mature. So far, there has been no reason whatsoever to alter them in the least.

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# X-RAY TECHNIC FOR CHILDREN<sup>1</sup>

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IN any survey of roentgenographic literature the surprising dearth of material dealing with technic for children will undoubtedly be noticed. Excellent instruction in adult technic may be given, but for child technic, if it is mentioned at all, the reader is offered some such vague direction as "halve the time of exposure for children." The all-too-familiar result of an instruction of that kind is either the transparent-like negative or the densely dark one, neither of which is satisfactory for diagnostic purposes. This article is an attempt to contribute more definite technic within a limited field.

The Iowa Child Welfare Research Station has been engaged in an x-ray program for the past twelve years. Its object has been to study, through this medium, growth and development of normal children from birth to maturity, correlating the results with findings through physical measurements. In anticipation of research projects along this line, the x-ray films have been limited to the bony structure of the body. Because of the greater amount of data on the head and the extremities (about 1,500 exposures), this article will be concerned with them alone. It is hoped, however, that a similar work on the soft tissues and on the other bone structure, not here mentioned, will be forthcoming.

For some years the radiographs were made at the College of Dentistry of the State University of Iowa under the direction of Dr. E. A. Rogers, and it is to his assistance that the writer is indebted for the technical details upon which the present methods have been built. Additional suggestions have also been made

from time to time by R. M. Tarrant, head technician at the State University of Iowa General Hospital. The aim has been to use such exposure as will show the maximum amount of detail in bone pattern and density and the earliest nuclei of bone growth. Since knowledge on the ultimate effect of x-rays is incomplete, an attempt was made to give each child the minimum exposure compatible with good results.

The equipment consisted of a Snook machine with which a Universal fine tube was used. Although this tube does not possess the smallest focal spot which is very desirable for ultra-fine bone work, its general practicality for combination service recommended it. A 1 mm. aluminum filter is used at all times. Formerly a target distance of 30 inches was maintained, but now one of 36 inches is used. The appreciation expressed by a seven-year-old and the greater confidence observed in the younger ones warrant this increase of distance, which at the same time affords greater safety. Because of the 6-inch increase, an addition of approximately 9 K.V.P. was necessary to give the same results. The change in distance alters the size of the image very slightly. Baldwin, Busby, and Garside<sup>2</sup> in their comparison of carpal area demonstrated that the variation is within the experimental error in measuring. The technic used in this study is adapted to Eastman Diaphax films, for Contrast films the exposure time was multiplied by 1.5.

The first part of this study deals with infants ranging in age from sixteen days

<sup>1</sup> This study was made at the suggestion and with the helpful advice of Miss S. Idell Pyle, of the Iowa Child Welfare Research Station.

<sup>2</sup> Baldwin, Bird T., Busby, Laura M., and Garside, Helen V. *Anatomic Growth of Children. A Study of Some Bones of the Hand, Wrist, and Lower Forearm by Means of Roentgenograms.* Univ. Iowa Stud. in Child Welfare, 1928, IV, No. 1, pp. 88.

to two years, five months, twenty-nine days. The prereading voltage and consequent secondary voltage, *i e.*, kilovolt peak, was the only variable used in this group. The second part of this article deals with children of school age from five years, six months, to seventeen years, five months, twenty-nine days, with whom it was possible to use time as the variable. The radiographs have been judged and classified for their adequateness by the writer and two other persons who have worked with the films. The technic here given is the one actually employed with those films which were satisfactory in every detail.

#### INFANTS

In the early part of this study, hand films of the first group were taken with a very short exposure. The method was for an assistant to place the hand rather suddenly on the film, surprising the child and causing him to hold his hand in position long enough for the exposure of about 0.1 second. Later, however, this method was discarded in favor of one simpler for the technicians, namely, that of holding the hand down with a piece of gauze. It was found that an exposure of 0.3 second could then be used with as high a percentage of accuracy as that secured by the first method. In other words, if the hand could be held at all, it could be held

for 0.3 second. The hand technic used is given in Table I.

No intensifying screens were used, instead, the films were placed in the black-and-orange envelopes supplied by the manufacturers. A piece of lead ( $\frac{1}{8}$  inch thick) was placed at the back of the outer envelope to obviate fogging by secondary radiation during the exposure. An interesting point was brought out when it was decided to take a radiograph of the mother's hand in order to compare its bone pattern with that of the child's hand. The writer was told that it would be impossible to make a single exposure that would give an adequate picture of the child's hand and at the same time show the mother's bone pattern. However, the writer felt justified in making the trial, believing that, even though the roentgenograms might not be as good as those obtained by two separate exposures, yet the added confidence given to the child in having his mother's hand alongside would be worth while. This proved to be true. Often with a child as young as fifteen months it was not necessary to hold the hand in position with gauze, as the child could be persuaded voluntarily to place his hand beside his mother's. Moreover, the mother's roentgenogram gave a considerable amount of detail and entirely filled the desired requirements. When it is realized that for the average

TABLE I—X-RAY TECHNIC FOR HANDS OF INFANTS FROM SIXTEEN DAYS TO TWO AND ONE-HALF YEARS OLD

Age						Prereading voltage	Kilovolt peak	Time (sec.)	Milli-amperes	Distance (in.)
Years	Months	Days	Years	Months	Days					
		16 to		1	15	106	60	0.3	50	36
	1	16 to		2	15	106 to 111	60 to 63	0.3	50	36
	2	16 to		3	15	106 to 111	60 to 63	0.3	50	36
	3	16 to		4	15	106 to 111	60 to 63	0.3	50	36
	4	16 to		5	15	111 to 116	63 to 66	0.3	50	36
	5	16 to		6	15	116 to 122	66 to 68	0.3	50	36
	6	16 to		7	15	122	68	0.3	50	36
	7	16 to		8	15	122	68	0.3	50	36
	8	16 to		9	15	122	68	0.3	50	36
	9	16 to		10	15	122 to 127	68 to 72	0.3	50	36
	10	16 to		11	15	122 to 127	68 to 72	0.3	50	36
	11	16 to		12	15	122 to 127	68 to 72	0.3	50	36
	12	16 to	1	5	29	127	72	0.3	50	36
1	6	0 to	2	5	29	132	76	0.3	50	36

TABLE II—HEIGHT AND WEIGHT RANGE OF INFANTS IN THIS STUDY

Years	Age			Years	Months	Days	Height range (in)	Weight range (pounds)
	Months	Days	to					
		16	to		1	15	18 7 to 22 1	9 0 to 11 50
	1	16	to		2	15	21 3 to 23 3	10 9 to 14 65
	2	16	to		3	15	22 5 to 24 1	12 5 to 14 55
	3	16	to		4	15	21 7 to 27 0	11 0 to 18 40
	4	16	to		5	15	24 6 to 28 0	13 7 to 19 30
	5	16	to		6	15	23 0 to 29 5	14 6 to 22 10
	6	16	to		7	15	25 5 to 29 3	16 1 to 23 30
	7	16	to		8	15	25 7 to 28 5	16 2 to 21 50
	8	16	to		9	15	26 5 to 30 0	17 6 to 25 50
	9	16	to		10	15	27 1 to 29 2	19 2 to 20 30
	10	16	to		11	15	28 9 to 30 3	21 6 to 26 70
	11	16	to		12	15	29 1 to 30 0	20 6 to 24 80
	12	16	to	1	5	29	27 4 to 32 5	17 5 to 26 14
1	6	0	to	2	5	29	29 4 to 36 9	20 4 to 33 10

TABLE III—MEAN HEIGHT AND WEIGHT FOR INFANTS<sup>3</sup>

Age (mo)	Boys		Girls	
	Mean height (in)	Mean weight (pounds)	Mean height (in)	Mean weight (pounds)
1	21 5	8 6	20 6	8 2
2	22 6	11 0	21 9	9 7
3	24 3	12 8	23 6	12 6
4	25 0	14 6	24 3	13 0
5	26 0	16 3	25 6	15 7
6	26 7	17 6	25 7	15 9
7	27 1	18 1	26 5	17 0
8	27 7	19 6	26 7	18 1
9	28 2	20 5	28 0	19 0
10	28 6	20 7	27 9	19 6
11	29 2	21 6	28 3	20 7
12	29 6	22 0	29 1	20 5
18	32 2	25 1	31 4	23 6
30	36 6	31 1	35 2	29 8

<sup>3</sup> Pyle, S Idell. Physical Traits of Iowa Infants  
Am Jour Dis Child, 1931, XLII, 1137-1143

woman's hand but 0.4 second more exposure is necessary than for that of the six-month-old child, the satisfactory results are not so surprising.

In classifying the infants' roentgenograms, groupings were made according to age, height, and weight. As a rule, previous investigators have emphasized the importance of the size of the individual in calculating the factors governing the technic used. It appeared that for the group used in this study, however, age was the prime factor to be used in controlling the technic, and the tables given here are arranged according to age. At the time of exposure the infant's age was not persistently ascertained, instead, a cursory appraisal of skeletal development usually

determined the operator's choice of kilovolt peak. Height proved to be an inadequate criterion. In a study of two groups, one ranging in height from 26.7 inches to 27.7 inches and the other from 30.7 inches to 32.5 inches, there was a variation of from 6 to 8 kilovolts peak. The inadequacy of height as a criterion is clearly shown by the great range in age within each of these groups. First group, children from five to thirteen months, second group, children from thirteen months to two years. Weight showed a still wider variation. A grouping of those weighing from 17 pounds, 6 ounces, to 21 pounds, 6 ounces, included children from four months to twenty-two months, fifteen days—children who would obviously require the use of differing kilovolt peak and who did actually run a range of 13 kilovolts peak. A second grouping of those weighing between 10 and 20 pounds included children from one month, nine days, to one year, five months, eight days, of age and ran a range of 12 kilovolts peak. In each group this showed but 3 KVP less than the whole gamut.

It would appear then that body weight of the infant is of less importance than height and of still less importance than age in determining x-ray technic to be used for exposures of the extremities. However, age cannot be taken as an absolute criterion, for just as different substances present resistance to the x-rays in varying degrees according to their atomic weight,

so also the individuals present a radio-opacity that varies possibly because of the differing constituency of the bone, fat, muscle, and skin components. For instance, the pattern of the bone in the really fat child will not be as clearly pronounced on the film as that of the normal child, although the contrasts and density indicate that the right exposure was given. It has been suggested that this condition is due to fat within the bone as well as tissue fat. The height and weight range of the children in this group is shown in Table II. Table III indicates that these infants were of average height and weight by giving the averages for boys and girls of these ages.

In taking roentgenograms of the foot, the child was either placed on the table

on his back or held in a semi-sitting posture by the assistant. Except in a few rare instances, no gauze was used to hold the foot in position. As this work is done primarily for research, an effort is made whenever possible to avoid distressing the child by such constrictions and to avoid distortion of the parts. For the antero-posterior view, the foot was placed in a walking position on the film, the assistant maintaining it in this position by holding the child's knee. Table IV gives the technic used.

The position for the lateral view of the foot is a very natural one for the infant and one that is usually unconsciously maintained without aid. Ordinarily 3 KVP more than the anteroposterior exposure gives the necessary voltage for

TABLE IV —X-RAY TECHNIC FOR ANTEROPOSTERIOR VIEW OF FOOT FOR INFANTS FROM SIXTEEN DAYS TO TWO YEARS, SIX MONTHS, OLD

Age						Prereading voltage	Kilovolt peak	Time (sec)	Milli-amperes	Distance (in)
Years	Months	Days	Years	Months	Days					
		16 to		1	15	111	63	0 3	50	36
	1	16 to		2	15	111 to 116	63 to 66	0 3	50	36
	2	16 to		3	15	111 to 116	63 to 66	0 3	50	36
	3	16 to		4	15	111 to 116	63 to 66	0 3	50	36
	4	16 to		5	15	116 to 122	66 to 68	0 3	50	36
	5	16 to		6	15	122 to 127	68 to 72	0 3	50	36
	6	16 to		7	15	127	72	0 3	50	36
	7	16 to		8	15	127	72	0 3	50	36
	8	16 to		9	15	127	72	0 3	50	36
	9	16 to		10	15	127	72	0 3	50	36
	10	16 to		11	15	127	72	0 3	50	36
	11	16 to		12	15	127 to 132	72 to 76	0 3	50	36
	12	16 to	1	5	29	132	76	0 3	50	36
1	6	0 to	2	5	29	137 to 141	80 to 83	0 3	50	36

TABLE V —X-RAY TECHNIC FOR LATERAL VIEW OF FOOT FOR INFANTS SIXTEEN DAYS TO TWO YEARS, SIX MONTHS, OLD

Age						Prereading voltage	Kilovolt peak	Time (sec)	Milli-amperes	Distance (in)
Years	Months	Days	Years	Months	Days					
		16 to		1	15	111	63	0 3	50	36
	1	16 to		2	15	116	66	0 3	50	36
	2	16 to		3	15	122	68	0 3	50	36
	3	16 to		4	15	122	68	0 3	50	36
	4	16 to		5	15	122 to 127	68 to 72	0 3	50	36
	5	16 to		6	15	127	72	0 3	50	36
	6	16 to		7	15	127 to 132	72 to 76	0 3	50	36
	7	16 to		8	15	127 to 132	72 to 76	0 3	50	36
	8	16 to		9	15	132	76	0 3	50	36
	9	16 to		10	15	132	76	0 3	50	36
	10	16 to		11	15	132	76	0 3	50	36
	11	16 to		12	15	132	76	0 3	50	36
	12	16 to	1	5	29	132 to 137	76 to 80	0 3	50	36
1	6	0 to	2	5	29	137 to 145	80 to 86	0 3	50	36

TABLE II—HEIGHT AND WEIGHT RANGE OF INFANTS IN THIS STUDY

Years	Age			Height range (in)		Weight range (pounds)
	Months	Days	Years	Months	Days	
		16 to		1	15	18 7 to 22 1
	1	16 to		2	15	21 3 to 23 3
	2	16 to		3	15	22 5 to 24 1
	3	16 to		4	15	21 7 to 27 0
	4	16 to		5	15	24 6 to 28 0
	5	16 to		6	15	23 0 to 29 5
	6	16 to		7	15	25 5 to 29 3
	7	16 to		8	15	25 7 to 28 5
	8	16 to		9	15	26 5 to 30 0
	9	16 to		10	15	27 1 to 29 2
	10	16 to		11	15	28 9 to 30 3
	11	16 to		12	15	29 1 to 30 0
	12	16 to	1	5	29	27 4 to 32 5
1	6	0 to	2	5	29	29 4 to 36 9
						20 4 to 33 10

TABLE III—MEAN HEIGHT AND WEIGHT FOR INFANTS<sup>1</sup>

Age (mo)	Boys		Girls	
	Mean height (in)	Mean weight (pounds)	Mean height (in)	Mean weight (pounds)
1	21 5	8 6	20 6	8 2
2	22 6	11 0	21 9	9 7
3	24 3	12 8	23 6	12 6
4	25 0	14 6	24 3	13 0
5	26 0	16 3	25 6	15 7
6	26 7	17 6	25 7	15 9
7	27 1	18 1	26 5	17 0
8	27 7	19 6	26 7	18 1
9	28 2	20 5	28 0	19 0
10	28 6	20 7	27 9	19 6
11	29 2	21 6	28 3	20 7
12	29 6	22 0	29 1	20 5
18	32 2	25 1	31 4	23 6
30	36 6	31 1	35 2	29 8

<sup>1</sup> Pyle, S Idell. Physical Traits of Iowa Infants. *Am Jour Dis Child*, 1931, XLII, 1137-1143

woman's hand but 0.4 second more exposure is necessary than for that of the six-month-old child, the satisfactory results are not so surprising.

In classifying the infants' roentgenograms, groupings were made according to age, height, and weight. As a rule, previous investigators have emphasized the importance of the size of the individual in calculating the factors governing the technic used. It appeared that for the group used in this study, however, age was the prime factor to be used in controlling the technic, and the tables given here are arranged according to age. At the time of exposure the infant's age was not persistently ascertained, instead, a cursory appraisal of skeletal development usually

determined the operator's choice of kilovolt peak. Height proved to be an inadequate criterion. In a study of two groups, one ranging in height from 26.7 inches to 27.7 inches and the other from 30.7 inches to 32.5 inches, there was a variation of from 6 to 8 kilovolts peak. The inadequacy of height as a criterion is clearly shown by the great range in age within each of these groups: first group, children from five to thirteen months; second group, children from thirteen months to two years. Weight showed a still wider variation. A grouping of those weighing from 17 pounds, 6 ounces, to 21 pounds, 6 ounces, included children from four months to twenty-two months, fifteen days—children who would obviously require the use of differing kilovolt peak and who did actually run a range of 13 kilovolts peak. A second grouping of those weighing between 10 and 20 pounds included children from one month, nine days, to one year, five months, eight days, of age and ran a range of 12 kilovolts peak. In each group this showed but 3 KVP less than the whole gamut.

It would appear then that body weight of the infant is of less importance than height and of still less importance than age in determining x-ray technic to be used for exposures of the extremities. However, age cannot be taken as an absolute criterion, for just as different substances present resistance to the x-rays in varying degrees according to their atomic weight,

by lead, were used as with the infants. A lateral view was taken of the head, an effort being made to procure a good film of the dental development of the left side of the head, upper and lower mandibles, depth and breadth of the ramus, the sella turcica, and the general contour of the skull. It was found that the best way to do this and to avoid superimposition of the parts was to give an 18- to 20-degree tilt of the tube toward the head. When the tube is thus tilted and 36 inches from

the table maintained, the central ray is elongated some 25 inches and a compensation of either distance, kilovolt peak, or time must be made. This, however, is taken into consideration and adjustment made in the technic given. The child is placed on the table in a prone position, the hands at the side and the head turned to the right. If it is necessary to improve the angle, a small pillow or sand-bag is placed under the chest.

Measurements were taken of the head

TABLE VIII —X-RAY TECHNIC FOR ANTEROPOSTERIOR VIEW OF FOOT FOR CHILDREN OF SCHOOL AGE

Age						Pre-reading voltage	Kilo-volt peak	Time (sec)	Milli-amperes	Distance (in)
Years	Months	Days	Years	Months	Days					
5	6	0 to 6	5	5	29	106	60	0 40 to 0 50	50	36
6	6	0 to 7	5	5	29	106	60	0 50	50	36
7	6	0 to 8	5	5	29	106	60	0 50	50	36
8	6	0 to 9	5	5	29	106	60	0 50 to 0 75	50	36
10	6	0 to 11	5	5	29	106	60	0 75	50	36
11	6	0 to 12	5	5	29	106	60	0 75 to 1 00	50	36
12	6	0 to 13	5	5	29	106	60	0 75 to 1 00	50	36
13	6	0 to 14	5	5	29	106	60	1 00	50	36
14	6	0 to 15	5	5	29	106	60	1 00 to 1 25	50	36
15	6	0 to 16	5	5	29	106	60	1 00 to 1 25	50	36
16	6	0 to 17	5	5	29	106	60	1 00 to 1 50	50	36

TABLE IX —X-RAY TECHNIC FOR LATERAL FOOT FOR CHILDREN OF SCHOOL AGE

Age						Pre-reading voltage	Kilo-volt peak	Time (sec)	Milli-amperes	Distance (in)
Years	Months	Days	Years	Months	Days					
5	6	0 to 6	5	5	29	111	63	0 50	50	36
6	6	0 to 7	5	5	29	111	63	0 50	50	36
7	6	0 to 8	5	5	29	111	63	0 50	50	36
8	6	0 to 9	5	5	29	111	63	0 50 to 0 75	50	36
10	6	0 to 11	5	5	29	111	63	0 75	50	36
11	6	0 to 12	5	5	29	111	63	0 75 to 1 00	50	36
12	6	0 to 13	5	5	29	111	63	0 75 to 1 00	50	36
13	6	0 to 14	5	5	29	111	63	1 00	50	36
14	6	0 to 15	5	5	29	111	63	1 00 to 1 25	50	36
15	6	0 to 16	5	5	29	111	63	1 00	50	36
16	6	0 to 17	5	5	29	111	63	1 00 to 1 50	50	36

TABLE X —HEIGHT AND WEIGHT RANGE OF SCHOOL CHILDREN IN THIS STUDY

Age						Height range (in)	Weight range (pounds)
Years	Months	Days	Years	Months	Days		
5	6	0 to 6	5	5	29	42 0 to 47 6	35 1 to 56 2
6	6	0 to 7	5	5	29	43 6 to 52 2	40 8 to 41 7
7	6	0 to 8	5	5	29	49 5 to 54 1	55 6 to 66 0
8	6	0 to 9	5	5	29	54 4 to 54 5	62 2 to 65 0
9	6	0 to 10	5	5	29	51 3 to 56 0	62 8 to 66 4
10	6	0 to 11	5	5	29	61 2	90 8
11	6	0 to 12	5	5	29	58 1 to 63 9	101 2 to 127 9
12	6	0 to 13	5	5	29	60 2 to 64 8	63 5 to 107 8
13	6	0 to 14	5	5	29	61 7 to 62 6	93 7 to 107 6
14	6	0 to 15	5	5	29	63 5 to 67 5	100 8 to 162 7
15	6	0 to 16	5	5	29	66 0 to 70 1	112 7 to 157 0
16	6	0 to 17	5	5	29	66 9 to 73 7	119 9 to 175 5

the added thickness of the lateral view. The technic used is given in Table V.

The data on the head technic for infants are not sufficiently complete to be presented here.

The lateral elbow was radiographed while the child was held on either the mother's or the assistant's lap parallel with the table. In an effort to support himself the child would so hold the elbow over the film as to give opportunity for the exposure. When an anteroposterior view of the elbow was required, the arm was held out by taking hold of the hand. The technic for exposure was in each case the same as that used for the anteroposterior foot. The anteroposterior view of the knee was not taken as a matter of routine. When it was required, the technic used was 3 K V P, or one unit, according to the calibration of the machine, above that used in the lateral foot technic for a child of the same age.

This completes the record of the technic used on the extremities of infants. It will be noticed that as the age increases the variation in the exposure factors becomes less. Several months might have been grouped together, as is done in the age-group from twelve months, sixteen days, to one year, five months, twenty-nine days, but the grouping of the months would have varied somewhat in each chart. Therefore, it was thought that the arrangement used was more consistent. It is obvious that as age increases the rate of growth decreases, and groupings covering a larger age range can thus be made.

#### SCHOOL CHILDREN

The x-ray exposures were limited to head, hands, and feet for the school-age children comprising the second group. Intensifying screens were used for the head exposures, but for the hands and feet the black-and-orange envelopes, backed

TABLE VI—X-RAY TECHNIC FOR LATERAL VIEW OF HEAD AND RANGE OF TRANSVERSE HEAD MEASUREMENTS FOR CHILDREN OF SCHOOL AGE

Age						Pre-reading voltage	Kilo-volt peak	Time (sec)	Milli-amperes	Distance (in)	Range	
Years	Months	Days	Years	Months	Days						Meatus	Parietal
5	6	0 to 6	5	5	29	106	60	0 30 to 0 50	50	36	11 0 to 11 8	13 8 to 14 8
6	6	0 to 7	5	5	29	106	60	0 40 to 0 50	50	36	11 0 to 12 0	13 2 to 14 2
7	6	0 to 8	5	5	29	106	60	0 40 to 0 50	50	36	11 4 to 12 2	13 2 to 14 6
8	6	0 to 9	5	5	29	106	60	0 40 to 0 50	50	36	11 6 to 12 4	13 8 to 14 6
9	6	0 to 10	5	5	29	106	60	0 50 to 0 75	50	36	11 6 to 12 2	13 8 to 14 6
10	6	0 to 11	5	5	29	106	60	0 75 to 1 00	50	36	12 4	14 2
11	6	0 to 12	5	5	29	106	60	0 75 to 1 00	50	36	12 6 to 13 8	14 2 to 14 6
12	6	0 to 13	5	5	29	106	60	0 75 to 1 00	50	36	12 0 to 13 0	14 2 to 14 8
13	6	0 to 14	5	5	29	106	60	1 00	50	36	12 6 to 13 6	14 6 to 15 2
14	6	0 to 15	5	5	29	106	60	1 00	50	36	13 2 to 13 8	14 4 to 15 4
15	6	0 to 16	5	5	29	106	60	1 00	50	36	12 6 to 13 4	14 4 to 14 8
16	6	0 to 17	5	5	29	106	60	1 00 to 1 50	50	36	12 8 to 14 0	14 2 to 16 2

TABLE VII—X-RAY TECHNIC FOR HANDS OF CHILDREN OF SCHOOL AGE

Age						Pre-reading voltage	Kilo-volt peak	Time (sec)	Milli-amperes	Distance (in)
Years	Months	Days	Years	Months	Days					
5	6	0 to 6	5	5	29	102	56	0 40 to 0 50	50	36
6	6	0 to 7	5	5	29	102	56	0 40 to 0 50	50	36
7	6	0 to 8	5	5	29	102	56	0 40 to 0 50	50	36
8	6	0 to 9	5	5	29	102	56	0 50	50	36
9	6	0 to 10	5	5	29	102	56	0 50 to 0 75	50	36
10	6	0 to 11	5	5	29	102	56	0 75 to 1 00	50	36
11	6	0 to 12	5	5	29	102	56	0 75 to 1 00	50	36
12	6	0 to 13	5	5	29	102	56	1 00	50	36
13	6	0 to 14	5	5	29	102	56	1 00	50	36
14	6	0 to 15	5	5	29	102	56	1 00	50	36
15	6	0 to 16	5	5	29	102	56	1 00	50	36
16	6	0 to 17	5	5	29	102	56	1 00 to 1 25	50	36

# POST-TRAUMATIC PARA-ARTICULAR OSSIFICATION OF THE KNEE JOINT ("KÖHLER-PELLEGRINI-STIEDA SHADOW")

By DR I M ODESSKY, *Moscow, U S S R*

From the Radiological Service of the Hospital, Prof Ostroumoff, Dr A Zeitlin, Director

THE knee joint, because of its anatomical position, is often exposed to varying forms of trauma. In the event of injury the first thought is of a bone lesion, and, because of possible fracture, the patient is sent to the radiographic department. If the report is in the negative, the condition is regarded as a simple contusion, its cure to be effected in a short time with proper treatment or even spontaneously. When the healing is prolonged and the patient continues to complain, other hypotheses may attribute these pains to alterations in the nervous system and even give rise to the suspicion that the patient is malingering. However, repeated radiographic examinations can, in many of these cases, settle the question.

In this paper we wish to consider the structures located at the internal condyle of the femur, described under the names of "Stieda shadow-fracture," "Stieda-Pellegrini fracture disease," "Kohler-Pellegrini-Stieda disease," etc. However, all these terms are inexact and do not correspond with the nature of the changes or the priority of the discovery, and we agree with Petignani that it is superfluous to designate by a proper name any of the bone lesions of the type under discussion. But even if we wished to follow the custom, it would be more correct to call these "Kohler-Pellegrini-Stieda concomitant shadows" or, as Petignani prefers, "Kohler-Pellegrini-Stieda syndrome."

In 1905, Kohler, while studying a film, noted for the first time an unusual shadow of the coxofemoral articulation and of the femur, which he regarded as due to an ossification of the connective tissue about the joint. At the same time Pellegrini described the clinical picture, radiology, and histology of a case of post-traumatic

ossification in the region of the internal condyle of the femur. These papers did not arouse any special interest and it was not until two years later, in 1907, that Stieda, at the Third Radiological Congress, called the attention of physicians to this structure.

Papers on the important work of Petignani, Bistolfi, and Fredet, dealing with the question of the concomitant shadow of the knee joint, have appeared during the last three or four years in France and Italy. This question has lost none of its importance even to-day, and a series of publications, with histories of cases, is sufficient proof of that. After an interval of seven years there will be found the works of Michelson, Andreesen, Temler, and Berner in the German literature. Only the editorial (18) which appeared in the "American Journal of Roentgenology and Radium Therapy," in 1932, and the work of Kulowski (7), in 1933, have been found in the American literature. It would seem that this subject has been sufficiently studied and that it is useless to discuss it further. However, we are not reviving it for the purpose of increasing the number of published cases, but in order to try to understand what is meant by the name "Kohler-Pellegrini-Stieda disease," because the nature of the concomitant shadow is not wholly clear, and there is still some question as to the underlying lesion.

It is a shadow (parallel, as a rule, to the bone in the direction of the metadiaphysis) disclosed by radiographic examination three to four weeks after an injury. The injury may be inflicted in either one of two ways: direct or indirect violence (a blow, wound, contusion, or fracture), or it may be a series of small, repeated injuries of an occupational or athletic nature. The struc-



to determine if they could be used as guides to radiopacity. Head calipers were used, the tips being placed on either side at the external auditory meatus. A second transverse measurement was made about two inches higher at the parietal eminence. These measurements are given in Table VI. Although they indicate a steady growth, they do not at this time present a definite guide to the x-ray technician, on the other hand, they are not without some significance.

In taking hand radiographs, the child was seated on a stool or chair by the table. Both hands were placed on the film and the one roentgenogram taken. Exception was made to this in the cases of large and fat children, in such instances the radius would be rotated if the hands were cramped together on the film. For the same reason the elbows of the other children were kept from spreading and dropped slightly. Table VII gives the hand technic.

For the foot x-rays the child was placed on the table in a supine position. For the anteroposterior view of the foot, the knee was flexed and the foot placed flat on the film as for walking. A 5- to 10-degree tilt of the tube toward the child was made for children over eleven years, six months, of age, and the central ray was

directed toward the heaviest part of the foot. The technic used is given in Table VIII.

For the lateral view of the foot the supine position of the body was maintained. The flexed knee was turned outward and placed upon a pillow for stability and comfort. The supine position of the body was preferred to the lateral one sometimes recommended for this view of the foot, because there appeared less rotation of the tibia and fibula and they were not superimposed upon the astragalus. Table IX gives the technic used for the lateral view of the foot.

The height and weight range of the children of school age is given in Table X.

In conclusion, it appears that the technic to be used for the infants' roentgenograms varies with the age of the child rather than with the height or weight. This variation, however, becomes less as the age increases. With the children of school age, age plus skeletal development must be the determining factors. In both groups an exception to general technical results is found in the case of the overfat child, for here the bone pattern will be less clearly pronounced although the general appearance of the film will be satisfactory.

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cases, in each of which a traumatism was recorded in the history

Case 1 (Service of Dr Zeitlin) Narrow, elongated shadow, 1 cm  $\times$  2 mm, sharp outlines, located in the region of the internal condyle from 2 to 3 mm from the latter, parallel to the bone, its density corresponding with that of the bone

Case 2 (Service of Dr Zeitlin) Oval shadow, distinctly osseous in structure, sharply outlined, occurring at the level of the internal condyle, from 6 to 7 mm from the bone, corresponding to the middle of the condyle Another shadow, the width and form of a rice grain, projected in the region of the internal intercondylar tubercle The interarticular space showed nothing of importance

Case 3 (Service of Dr Zeitlin) Greatly elongated shadow formed of separated bands of varying degrees of density, occurring at the level of the superior border of the internal condyle of the femur, distinct from the bone Its upper border is indistinct Lower, towards the middle of the condyle, there is a group of small, dense shadows the size of a millet seed Another shadow composed of small, rounded bands with indistinct edges is located near the inferior edge of the external condyle, from 4 to 5 mm from the bone The radiographic film shows two shadows, one in the region of the popliteal fold behind the condyle, the other near the head of the fibula In addition, there is a fissure in the upper third of the patella Two other shadows, rice-like in form, project in the region of the intercondylar tubercle

Case 4 (Service of Dr Zeitlin) Approximate with the internal condyle is a band, fairly large, with sharp outlines, bony structure, the upper part of which is hidden by the metaphysis of the femur Another dense shadow, less voluminous, separated from the bone by a space of from 2 to 3 mm, is seen opposite the external condyle of the femur

Case 5 (Service of Dr Zeitlin) Elongated shadow separated from the femur by a space of from 2 to 3 mm, in the



Fig 5, Case 5

region of the superior border of the internal condyle of the femur Its density is the same as that of the bone Another structure of lesser density, vaguely triangular in shape, can be seen above the inferior edge of the internal condyle, from 3 to 5 mm from the bone

What is, therefore, the anatomical basis for these structures? Stieda, considering the position of the shadow, admits that it is a fracture of the upper part of the condyle of the femur His conclusion is based on a comparison made with an anatomical specimen presenting analogous changes Vogel reached the same conclusion from a case operated on, verified by histologic examination The structure of the portion removed was entirely bony, without trace of periosteum or other connective tissue However, Vogel remarks that he did not notice at the operation the uneven outlines of the femur characteristic of a rupture Schaanning, on the other hand, having seen a case two days after injury, showing in the radiograph a shadow in juxtaposition to the internal condyle, which he removed surgically, does not admit of the possibility of ossification at the expense of the periosteal tissue



Fig. 1 (*top left*), Case 1, Fig 2 (*top, right*), Case 2, Fig 3 (*lower, left*), Case 3, Fig 4 (*lower, right*), Case 4

tures are generally of medium thickness, elongated form, varying degrees of density, separated from the bone by a clear space, sometimes attached to the bone by a pedicle or even fused with it. The clinical symptoms are indefinite, manifesting themselves, in the majority of cases, by vague, painful sensations.

The number of cases published up to the present time totals 300, most of them showing unilateral changes, rarely bilateral, and occasionally multiple alterations. Exceptionally there may be calcification in the region of the intercondylar tubercle.

Following are cited some of the typical

abundantly developed in the region of the knee joint, particularly on its internal aspect Kulowski (7), considering his material histologically and surgically, compares the Pellegrini-Stieda disease to ossifying myositis and finds the same conditions of metaplastic hyperplasia of the tissues underlie each process He argues most instructively against the rupture and against the periosteal origin of the concomitant shadow, having seen a recurrence at the same site two and a half months after operation Kulowski explains this fact by the surgical trauma and precocious mobilization of the limb already sensitized to the production of bony tissue He warns against all surgical intervention before the completion of the process of ossification Kulowski's explanation agrees with Pellegrini's ideas on this question

From the literature we glean three possibilities for the appearance of the concomitant shadow, as follows Separation of a bony fragment, periosteal ossification, and calcification of the soft parts with subsequent ossification Let us consider each of these in turn It can only be a question of detachment if (1) the shadow be revealed by the radiograph immediately following injury, proof of which is lacking, except for the cases of Schaanning and Andreessen in which, as a matter of fact, such structures were not disclosed until from three to four weeks after the injury, and the actual time of their appearance remains unknown (2) The shadow is generally shaped like a hook with sharp outlines and not typical of a rupture Also in the radiograph the femoral condyle shows no change as regards the position of the shadow Even in the cases operated on in which the bony lamella was removed, there was no indication of change in the femur or of roughness in its contours It seems very difficult to suppose that separation of a fragment of varying form and dimensions would not result in alterations in the contour of the femur (3) Against the question of fracture there is the fact that the concomitant shadow shows a tendency to grow, and to change in form,

structure, and density We cite a case from our practice Two months after a contusion, in a radiograph of the elbow (Case 6), there could be seen a light shadow, regarded as a site for the deposit of lime salts Another radiograph made one month later revealed at the place of the aforementioned shadow four isolated structures, round and oval, of bony consistency, separated from each other as well as from the bone by clear spaces (4) The shadow may diminish in size and even disappear (Kohler, Draudt)

(5) The appearance of a shadow even immediately after a trauma is not absolute proof of a separation, because it could also be the result of an old bone lesion For example, a radiograph of the talocrural joint taken the day after contusion showed a fracture of the fibula and a narrow shadow, sharply outlined, along the internal malleolus, separated from the bone by a clear space of from 3 to 4 mm, and regarded as a calcification of the soft parts In questioning the patient we learned that five months before, while playing football, he received a blow in the region of the internal malleolus (Case 7)

Several authors admit the possibility of the incidence of the shadow following periosteal ossification, but in that event it would be necessary for it to be connected with the bone in one way or another The free space, clearly outlined, between the shadow and the bone is an argument against the periosteum taking part in the structure of the shadow, to say nothing of the fact that periosteal separation is anatomically extremely rare

That the concomitant shadow may be the result of calcification and ossification of the soft parts is confirmed by the following The bilateral character of the shadows, their multiplicity, structure, shape, and position, by the free space between the shadow and the surface of the bone, and the deposit of lime salts seen simultaneously although more rarely in the region of the intercondylar tubercle With technically irreproachable radiographs one can easily distinguish between

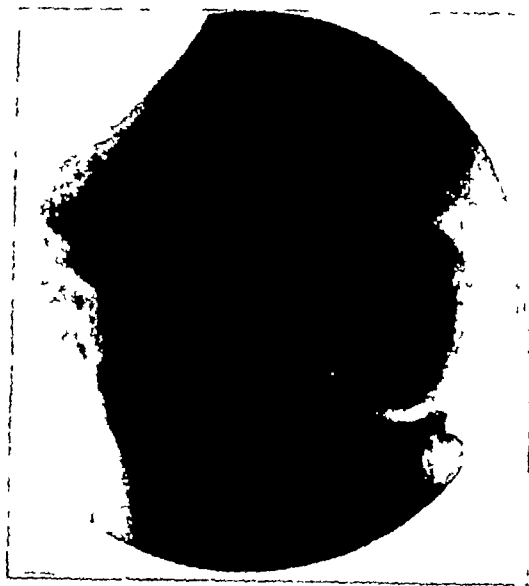


Fig 6, Case 6



Fig 7, Case 7

and speaks of the separation of a bony lamella. Andreesen (1), in analyzing his large material, quotes only two cases of actual fracture in support of the extreme rarity of these fresh injuries. Preiser speaks of "periosteal ossification," also called ossification of the separated periosteum. According to Berner (3) trauma and, in particular, subperiosteal hemorrhages, result in alteration of the periosteum, its separation, or even the tearing off of fragments of it. The degenerated periosteum produces bony tissue which later fuses with the femur. This is a question of periosteal ossification of a traumatic origin. Ollier's theory is that the ruptured periosteum takes with it the embryonal cells of the young osteoblasts which quickly produce bone in the surrounding infiltration, so that it is fairly difficult to judge whether it is a post-traumatic ossification or perhaps a torn-off fragment of bone.

Pellegrini in his first paper on the nature of the concomitant shadow rejects the idea of a fracture of the bone in favor of a metaplasia of the connective tissue. In 1927 he expanded the first hypothesis by admitting that there could be various

causes for the post-traumatic ossification, the most important of which might be the proliferation of the periosteum and metaplasia of the ligaments. According to Pfister, the concomitant shadow was the result of parosteal ossification, and he suggested for all similar structures the general designation of "callus without fracture," which means ossification of the periparosteal tissue resulting from a blow.

Others, such as Finochietto, Fiorentini (5), Bistolfi, Pettrignani (11), and Mutel, Girard, and Branche, believe a hematoma should be considered as the cause of the concomitant shadow, the latter being a favorable site for the deposit of lime salts.

Temler (15), on the other hand, gives the following explanation. The form and position of the concomitant shadow exactly correspond to the intermuscular space between the adductor magnus and the vastus internus. The conditions for the resorption of the hematoma in this region are unfavorable, and he thinks that there results a calcification of small hematomas in consequence of capillary hemorrhages. This explanation seems nearer the truth because the collateral network is

# THE HEALING OF CAVITIES IN PULMONARY TUBERCULOSIS ROENTGENOGRAPHICALLY OBSERVED<sup>1</sup>

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ROENTGENOLOGY has a right to be proud of the part it has played in developing the modern treatment of pulmonary tuberculosis. The memory of most of us extends back to the time when clinicians scouted our timorous suggestion that we could offer valuable aid in diagnosing tuberculosis and following the progression or retrogression of its tissue changes. To-day, we have difficulty in keeping pace with the claims of this same group regarding the important place of our art in clinical medicine. It is a clinician, and not a roentgenologist, who is responsible for the assertion that activity in the tuberculous lung cannot be detected by the stethoscope so positively as it can be shown by the x-ray film. It is a clinician, and not a roentgenologist, who has stated that we must depend on the x-ray appearances, rather than on physical signs or symptoms, to indicate when a lung lesion is healed. It is a clinician who asserts that only 60 per cent of cavities are found by physical examination, while 95 per cent of them are shown by x-ray examination. We modestly agree to these statements, at the same time calling attention to the fact that they are not the claims of over-enthusiastic x-ray specialists, but the matured confessions of eminent clinicians who are experienced in the observation and treatment of tuberculosis.

Graeff's statement, in 1921, that development of a lung cavity is a death sentence for the unfortunate tuberculous patient, marked off a new epoch in the treatment of the disease. Not all workers are in entire agreement with this gloomy prognosis, but, in spite of numerous exceptions, the majority of critical observers accept it as substantially correct—Pinner, Fischel, Barnes and Barnes, and Sprung-

man, among others. There are, of course, many kinds of cavities, of various sizes and locations in the lung-field, and such a general statement as that by Graeff naturally is subject to many exceptions. However, so universally is it now accepted that the modern phthisiologist adopts as the basis for the treatment of lung tuberculosis that "the cavity must be closed," and persistently follows the indicated course to bring this about, whether that course be medical or surgical.

Avoiding statistical data and clinical reports, this paper aims to present the subject by a series of cases of increasing complexity and difficulty, in order to illustrate how the problems of cavity formation are met and solved. Particularly does this presentation aim to illustrate the necessity for close co-operation among clinicians, surgeons, and roentgenologists in solving the problems of diagnosis and

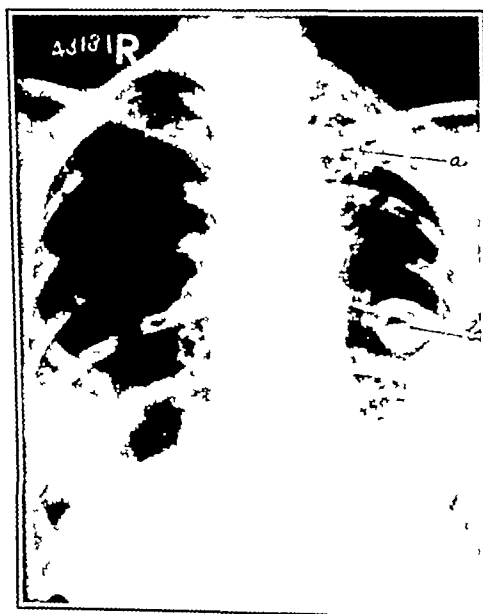


Fig 1 Case I. Roentgenogram (Nov 30, 1929) showing two cavities on the left side, one at apex (a), and the other 4 cm. in diameter just below hilus level (b).

<sup>1</sup> Presented before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28-Dec. 1, 1932.

the process of calcification and that of ossification

Here are, briefly, some histologic examples which confirm the possibility, under certain conditions, of the transformation of the soft parts into bony tissue. In the case cited by Schuller-Weil there is noted an intratendinous metaplastic ossification where the formation of bone has taken place in part directly, and in part by metaplasia of the cartilage. A case of Fiorentini (5) shows all the phases in the histologic picture of metaplasia from the cartilaginous stage to the mature osteoid tissue. Fiorentini believes that this is a question of post-traumatic hemorrhage in which the resorption took the form of young connective tissues, degenerating finally into osteoid tissue. Histologic examination of Kulowski's case shows three principal stages in the development of the bone. Infiltration of the connective tissue, the formation of a callus, finally, more rarely, enchondromatous ossification.

Study of the histologic specimens argues against fracture and proliferation of the periosteum, but in favor of metaplasia of the tissues. This fact is admitted at the present time by the majority of authors and confirmed also by our own observations.

Bearing in mind the above, one question presents itself. Is it correct to speak of the Köhler-Pellegrini-Stieda disease? Our reply can only be in the negative, because, in reality, it is not at all a question of a "disease," but a local ossification process, the final result of a post-traumatic alteration. Its mechanism is identical with that of calcification in other tissues, such as the pleura, pericardium, pancreas, etc. As to designating this structure by the name of a writer, there is the question of whether it pertains exclusively to the knee joint. As we have just seen, similar shadows are found as well in other joints (leg, shoulder,

elbow) exposed to injury. In addition, the so-called Köhler-Pellegrini-Stieda disease is nothing more than a calcification or ossification of the region of the knee joint, showing no consistent uniformity in clinical history for such classification, but forming a part of the general conception of post-traumatic, para-articular ossification.

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co-operation by the patient, in one method after another, until final success is achieved. Probably one-half of the cavities found in patients coming to physicians qualified to treat tuberculosis can be healed by simple or modified bed rest. Another one-fourth can be closed by pneumothorax. The remaining one-fourth will require the assistance of a chest surgeon for such procedures as phrenicectomy, intrapleural and extrapleural pneumolysis, and thoracoplasty. The special point to be kept firmly in mind from the outset is that the closure of the cavity is the aim of the treatment, since any method which will bring this about will also heal the exudative inflammation. The final success of the treatment will depend on the healing of the cavity and its replacement by scar tissue, as shown by the roentgenographic examination.

When cavities first develop, or when a patient first comes under the observation of the physician, the simplest methods are instituted unless it is obvious, from the history of the case, or the nature of the lesions, that such measures are doomed to failure. In determining this point, the x-ray findings assume a dominant place, and the interpretation of the roentgenologist on the basis of tissue pathology becomes supremely important. While under treatment, the cavity should be observed at frequent intervals by x-ray examination, as this is the only certain means of determining whether it is enlarging or healing. It is essential that this shall not be neglected, because simple methods must not be persisted in if they are not succeeding. The cavity must be closed, and if it becomes evident that a simple bed rest regimen will not be successful, more radical measures must be adopted. The measures ordinarily used for bringing about the closure of cavities are (1) Simple bed rest, (2) postural bed rest, (3) bed rest with weights on chest, (4) phrenicectomy, (5) pneumothorax, unilateral or bilateral, (6) pneumothorax with intrapleural pneumolysis, unilateral or bilateral, (7) extrapleural



Fig 5 Case III Roentgenogram (October, 1927) showing large cavity in upper left lung-field (a), with surrounding exudative density

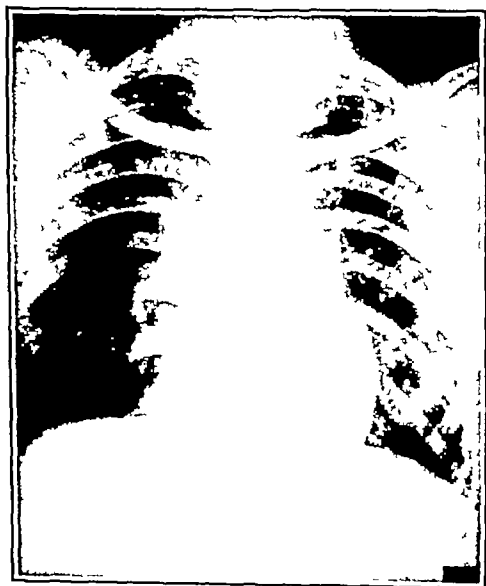


Fig 6 Case III Roentgenogram showing cavity closure after seven months' rest in bed with ten-pound shot bag over cavity

pneumolysis, (8) thoracoplasty, (9) combinations of two or more of these.

Bed rest is the oldest and basic method of treating tuberculosis and is also the most efficient in closing certain types of cavities. Even large cavities will often heal with simple bed rest, especially if



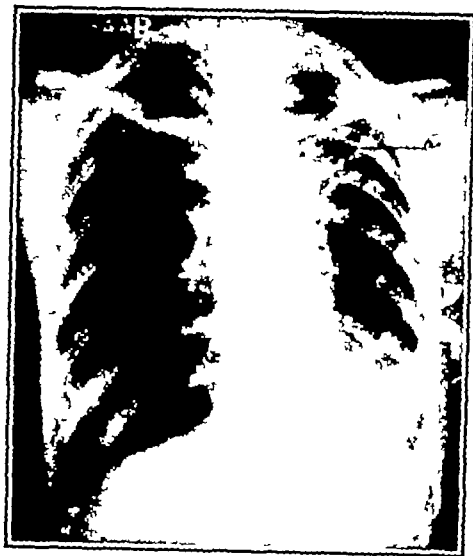


Fig 2 Case I Roentgenogram (Sept 5, 1930) showing complete disappearance of the cavity near hilus, under simple bed rest



Fig 4 Case II After four months' postural rest, cavity in lower left lung-field has disappeared



Fig 3 Case II Roentgenogram (Dec 1 1928) showing large cavity below left hilus (a) close to heart border with some infiltration in lower right lung field

treatment of lung cavities of tuberculous origin

It must be remembered that, whatever the size and appearance of the cavity, it is the product of a single pathologic process in different stages. The structure of the cavity depends on the degree

of fibrosis which indicates the stage of its developmental cycle. "The interplay of caseation, liquefaction, resorption, and fibrosis, with the mechanical conditions within the lung parenchyma, accounts for the structural differences of cavities at given times in their development" (Pinner). Such changes can best be followed by serial x-ray examinations, and the structural changes shown by roentgenograms are more important than location or size of cavities, as indications for treatment.

During the clinical management of tuberculosis, the development of cavitation represents an emergency calling for special treatment. A tuberculous patient who develops a cavity as large as an inch in diameter has an average life expectancy under ordinary treatment of only a year (Barnes and Barnes). Some live longer, but the hope for permanent arrest or cure of the disease depends on the closure of the cavity, since it cannot heal until its walls are brought in contact and thus held long enough for scar tissue to form. To secure closure of the cavity and its final healing may tax the patience and ingenuity of the physician and surgeon, and call for the utmost in faithful

tomed to them and sleep with the bags in place (In one case reported by Dr Holmes a shot bag weighing 27 pounds was used with good results)

Many cases of cavity healing under simple or modified bed rest could be cited, but three illustrative ones will suffice

**Case I** A roentgenogram of Nov 30, 1929 (Fig 1), shows two cavities on the left side, one at the apex (*a*), and the other (4 cm in diameter) just below the hilus level (*b*) On bed rest alone, by September, 1930, the large cavity at the hilus level had entirely healed (Fig 2), although the one at the apex had not yet closed This illustrates the relative ease with which healing of a centrally located cavity may be secured, as compared with one located at the lung surface over which pleural adhesions quickly form

**Case II** A roentgenogram of Dec 1, 1928 (Fig 3), shows a large cavity below the left hilus (*a*), close to the heart border, with some infiltration in the lower right lung-field This patient was placed on postural rest and in four months, as shown by Figure 4, the cavity in the left lung-field entirely disappeared Note also the shortening of the chest cavity because of the patient's gain in weight and the consequent lifting of the diaphragm

**Case III** A roentgenogram made in October, 1927 (Fig 5), shows a large cavity in the upper left lung-field, with a surrounding inflammatory infiltration Under seven months' rest in bed with a ten-pound shot bag over the cavity, the lesion and its surrounding inflammatory zone entirely disappeared (Fig 6)

**Phrenicectomy**—While paralysis of one leaf of the diaphragm, by removal of a section of the phrenic nerve, the so-called phrenicectomy, is a procedure of comparatively recent application in the treatment of lung cavities, and is classed as a surgical method, it is mentioned next in order to preserve the arrangement of increasing complexity It is a very simple means of treatment and will sometimes be efficient when bed rest, simple or modified, and pneumothorax have failed It is the most



Fig 10 Case V Roentgenogram (October, 1929) showing involvement in upper right lobe, with cavity formation (*a*)

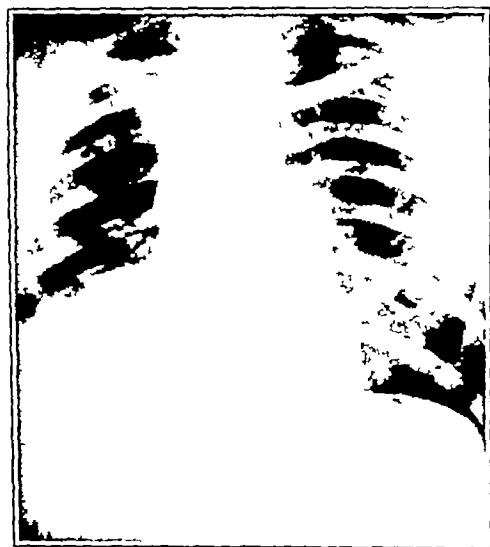


Fig 11 Case V Cavity healed following phrenicectomy

economical of all methods of obtaining rest for the diseased lung Unfortunately, it is applicable to a selected group only, but within that group has proven very satisfactory The elevation and paralysis of one leaf of the diaphragm mechanically displaces the underlying abdominal organs and sometimes causes unpleasant symptoms Two illustrative cases are cited



Fig 7 Case IV Condition on June 14, 1929, with extensive coalescing densities and cavitation in upper right lung showing exudative lesions along heart border as low as diaphragm



Fig 9 Case IV Condition in October, 1930, with closure of cavity in the upper lobe



Fig 8 Case IV Condition on Dec. 10, 1929, after phrenicectomy on the right. Much of the exudative type of density has disappeared, and cavity has decreased noticeably in size (c)

recent and centrally located (Fig 1). The localization of the cavity and the evaluation of the surrounding lung involvement by stereoroentgenograms will frequently indicate whether the cavity is likely to heal with bed rest alone, or

whether such a regimen is doomed to fail, thereby justifying the clinician in proceeding immediately to more radical treatment. The importance of bed rest is not minimized by this relatively brief discussion. It remains the most important factor in treating any tuberculous lesion and, as stated, 50 per cent of cavities will heal under rest alone, when this is consistently and persistently carried out.

When simple rest in bed, rigidly enforced, is not efficient, it may be supplemented by postural rest. Under this régime the patient lies, over long periods, in that position which will diminish the size of the cavity and limit the respiratory motion of the surrounding lung. Like simple rest, it is most beneficial when the lesions are recent and the cavity walls subject to collapse.

A still further modification of rest is to lessen the chest motion over a limited area by means of weights, usually canvas bags of shot. When the cavity is in the upper lung-field, or is apical, and especially when there are bilateral cavities, this simple method is worthy of trial. Bags up to ten pounds in weight are readily borne and patients soon become accus-

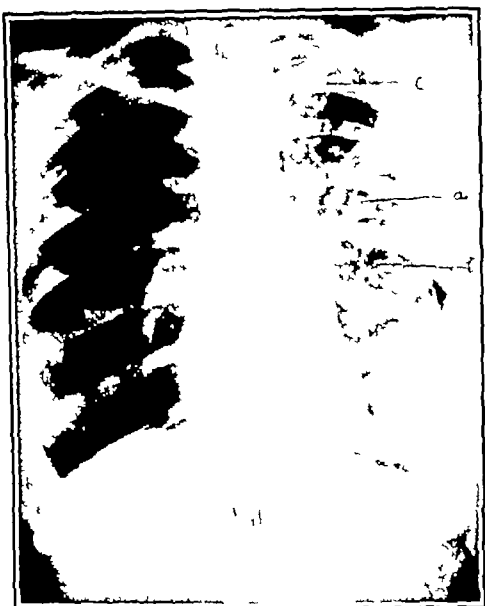


Fig 14 Case VII Roentgenogram (April 25, 1929) showing cavities (a), (b), and (c), with exudative densities through upper left lung-field

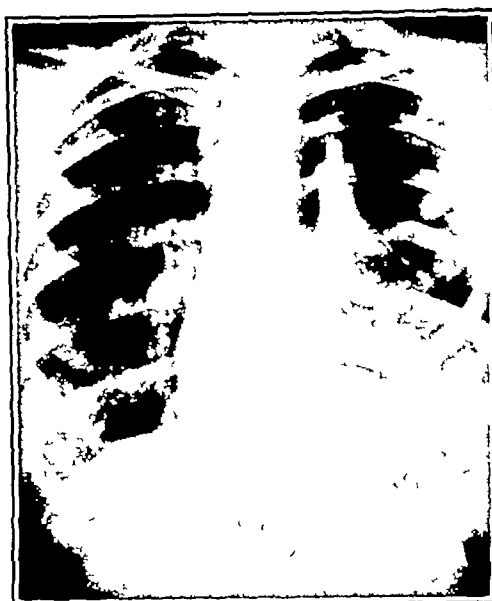


Fig 15 Case VII Selective collapse of the upper left lobe closing the cavities and with the lower lobe expanded and functioning

1931 (Fig 13), shows the lung still being held under compression over two years later. The large cavity is entirely closed, the air pressure being sufficient to cause slight displacement of the heart to the right. This patient, a physician, returned to his Eastern practice with the lung still compressed, and was still keeping it so when information was last received from him.

*Bilateral Pneumothorax*—In cases of bilateral cavitation, or in the event of cavitation developing in the functioning lung after pneumothorax has been established on the opposite side, the situation can frequently be handled with bilateral pneumothorax, or simultaneous compression of both lungs sufficiently to close the cavities. This seemingly radical treatment is astonishingly well borne. The functioning lung tissue can be reduced to a fraction of that ordinarily used, without great inconvenience, providing this is done gradually. On the Continent bilateral pneumothorax is quite extensively employed and is rapidly coming into favor in this country. Needless to say, frequent x-ray observations are essential in order to



Fig 16 Case VII Roentgenogram (April 22, 1931) showing distinct cavitation in the right lung (a), and satisfactory collapse still maintained on the left side

carry on this procedure accurately. I cite one illustrative case.

Case VII. A roentgenogram of April, 1929 (Fig 14), shows multiple cavities



Fig 12 Case VI Roentgenogram (June 23, 1928) showing huge cavity involving almost entire upper left lung-field (c, c)



Fig 13 Case VI Roentgenogram (Oct. 15, 1931) made nearly two years after establishment of pneumothorax on the left side

Case IV A roentgenogram made on June 14, 1929 (Fig 7), shows extensive coalescing densities and cavitation in the upper right lobe, with exudative lesions along the heart border as far as the diaphragm Phrenicectomy was done and the roentgenogram of December, 1929 (Fig 8), shows marked improvement. Note the height of the immobile diaphragm

and disappearance of much of the exudative shadow The cavity has diminished in size Ten months later, in October, 1930, a roentgenogram (Fig 9) showed disappearance of all basal densities, closure and healing of the upper right lobe cavity, and change from the exudative to the fibrotic type of shadow The higher position of the diaphragm is due to the patient's gain in weight

Case V A roentgenogram made in October, 1929 (Fig 10), shows upper right lobe involvement, with cavity formation, the left lung being free from significant shadow Phrenicectomy was done, followed by complete closure and healing of the cavity, as shown by the film made in October, 1931 (Fig 11)

*Artificial Pneumothorax (Unilateral)*—Undoubtedly the oldest, most popular, and widely used procedure specifically directed toward the closure of cavities is artificial pneumothorax It is a simple method, offering a maximum of success with a minimum of danger So many papers have been written on this subject that it is thoroughly familiar to all of us As simple as the method is, it still requires good judgment, careful technic, and the most sympathetic co-operation between patient and physician, as well as frequent roentgenologic study Not too long a time should be consumed in trying simpler methods, if it is at all likely that pneumothorax may have to be used, because there is an ever-increasing danger that adhesions will form and prevent the compression, especially when the cavity lies close to the pleural surface Either phrenicectomy or intrapleural pneumolysis can often be used as an adjunct to pneumothorax, in order to secure more perfect closure of the cavity One typical case, from many that could be cited, will suffice for illustration

Case VI A roentgenogram taken in June, 1928 (Fig 12), shows a huge cavity involving almost the entire upper left lobe This was placed under pneumothorax, the lung fortunately being found free from adhesions The roentgenogram of October,



Fig 21 Case IX Roentgenogram (February, 1930) showing large cavity in the upper left lobe (a), with surrounding infiltration

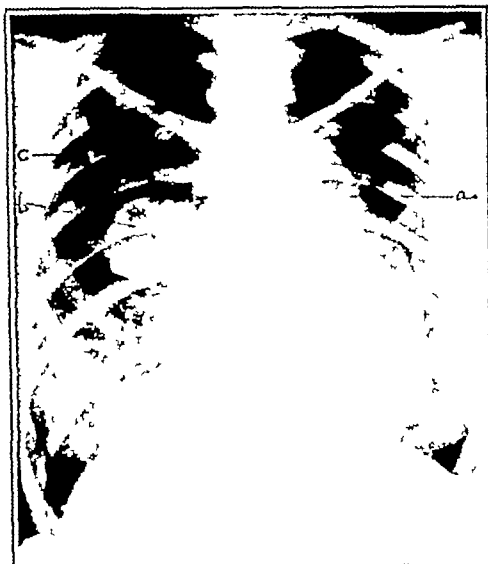


Fig 23 Case IX Condition after intrapleural pneumolysis had freed the adhesions on the left, and pneumothorax had been instituted on the right

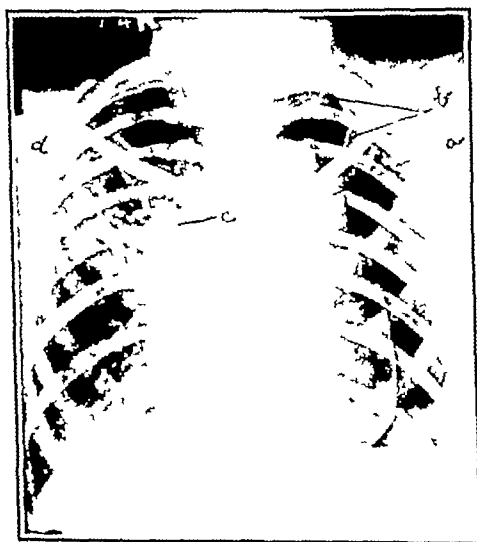


Fig 22 Case IX Showing incomplete closure of cavity on the left and extension of the process on the right



Fig 24 Case IX Condition on March 4, 1932 Cavity has been closed on the left The adhesion on the right has been freed by intrapleural pneumolysis, and this cavity has almost entirely closed (a)

lung The right lung was now compressed, and in March, 1932 (Fig 17), cavities were being held closed by selective compression on each side After about a year of this treatment, both lungs were allowed to re-expand, and the cavities remained closed, with the patient in good health

*Intrapleural Pneumolysis*—The attempt to close cavities by pneumothorax frequently fails because adhesions to the

chest wall prevent satisfactory compression of the cavity In suitable cases, these adhesions can be burned through by the method of Jacobæus, or intrapleural pneumolysis It may be remarked, in passing, that this procedure is little more



Fig 17 Case VII Roentgenogram (March 23, 1932) showing bilateral pneumothorax, with selective collapse closing cavities in each upper lobe, and with lower lobe of each side functioning



Fig 19 Case VIII Showing extent of collapse, by pneumothorax, incomplete on account of adhesions (b)

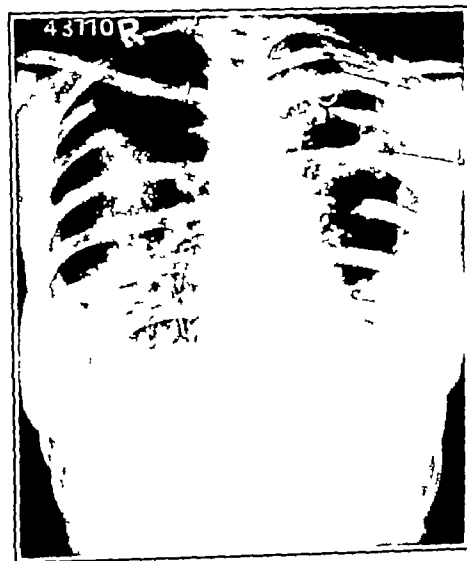


Fig 18 Case VIII Roentgenogram (Jan 13, 1928) showing fairly extensive involvement of the upper left lung-field, with multiple small cavities (a), (b)

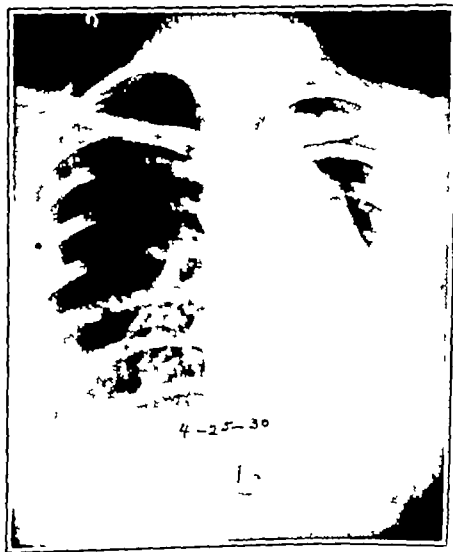


Fig 20 Case VIII Showing conditions after intrapleural pneumolysis

(a), (b), (c), with exudative shadow through the left lung. The right lung was free from abnormal shadow. The left lung was placed at rest by pneumothorax, the condition in March, 1930, being shown by the roentgenogram seen in Figure 15, with

upper lobe cavities closed and the lower left lobe expanded and functioning. In April, 1931, the patient returned from a summer spent in the East, during which time no x-ray observations had been made, with conditions as shown in Figure 16. The left lung was still held under compression closure, but definite involvement and cavity had developed in the upper right

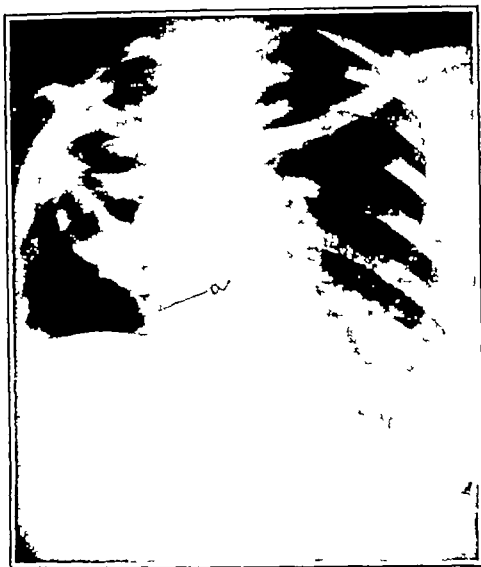


Fig 28 Case XI Condition after unsuccessful attempt to collapse the cavities by pneumothorax, supplemented by phrenectomy



Fig 29 Case XI Condition in June, 1931, after second stage of thoracoplasty Immobility of mediastinum resulted in incomplete closure of cavity (a) This has since been closed by paraffin filling

in the upper left lung-field, with surrounding infiltration. This was placed under pneumothorax (Fig 22), but the cavity was not entirely closed (a) on account of limiting adhesions. There was now observed also an extension of the disease in the right lung, with cavity formation (d). The adhesions were first freed by burning on the left side, resulting in almost complete closure of the cavity (a) (Fig 23). Pneumothorax was instituted on the right side, but the cavity (b) was held open by adhesive bands (c). After the adhesive bands had been freed on the right, a roentgenogram of March, 1932 (Fig 24), showed the cavity on the left to be closed, and the one on the right almost obliterated. Note how little functioning lung tissue is required to maintain comfort. This patient is ambulant and can climb stairs without dyspnea.

**Extrapleural Pneumolysis**—In an occasional case in which there are large apical cavities and pneumothorax cannot be established on account of adherent pleural surfaces, extrapleural pressure can be used to bring the cavity walls into apposition. The use of paraffin wax is one method which, while it has many drawbacks and a limited application, on the occasional

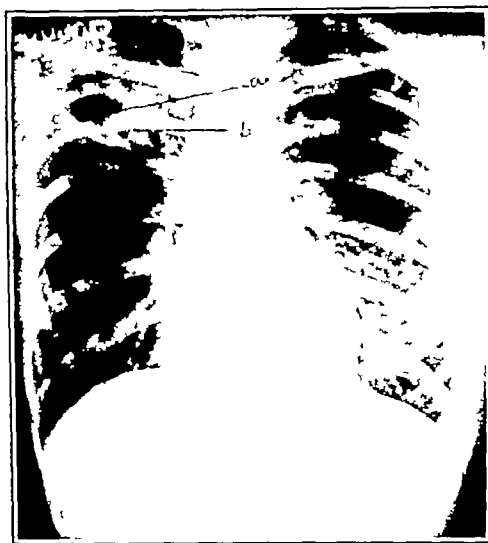


Fig 30 Case XII Roentgenogram (March 1929) showing large cavities in upper lobe of right side (a)

case permits one to avoid doing a thoracoplasty.

**Case X** A roentgenogram of March, 1931 (Fig 25), shows a very large cavity in the upper right lung-field (a), with surrounding infiltration, and some exudative involvement in the upper left lobe. Pneumothorax was tried and failed on account of an adherent pleura. The cavity was



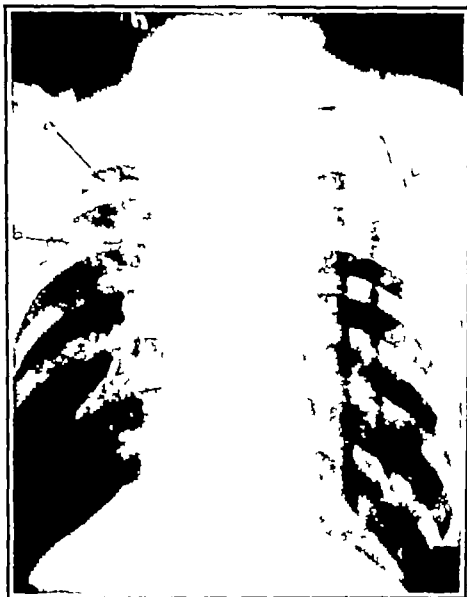


Fig 25 Case X. Condition of lungs in March, 1931, with very large cavity in upper right lung-field (a)



Fig 26 Case X. Condition after obliteration of cavity by extrapleural pneumolysis (paraffin filling)

than a modification of peritoneoscopy, developed by Orndoff in this country. The instruments used are quite similar to the peritoneoscope of Orndoff, with the addition of a cutting or cautery knife. No

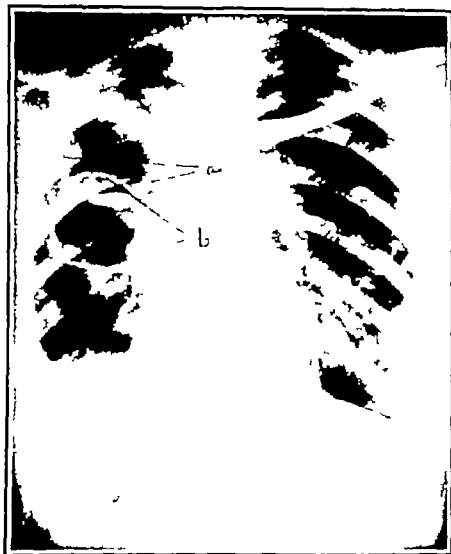


Fig 27 Case XI Roentgenogram (June, 1930) showing very large double cavity (a), (b), occupying most of upper two-thirds of right lung

procedure in the chest requires closer cooperation between surgeon and roentgenologist, nor more critical interpretation of roentgenographic and fluoroscopic findings. Just where the adhesion bands are attached, their relation to underlying lung tissue, whether they incorporate air-containing lung or are entirely fibrous, are some of the vital questions which the roentgenologist must aid in solving.

Case VIII. A roentgenogram of January, 1928 (Fig 18), shows fairly extensive involvement of the upper left lung-field, with multiple cavities (a), (b). This lung-field was placed under pneumothorax compression, which did not succeed in closing the cavities on account of adhesions. Note in the roentgenogram of July, 1928, that the lung is compressed everywhere except at the desired points (Fig 19). These adhesions were then freed by intrapleural pneumolysis, with satisfactory closure of the cavities and adjacent lung (Fig 20), the basal portion of the lung remaining open and functioning (selective collapse).

Case IX. A roentgenogram of February, 1930 (Fig 21), shows a large cavity



Fig 34 Case XIII Roentgenogram (February, 1929) showing extensive cavitation and much surrounding exudative density through lung-field on the right. Cavities at (a), (b), and (c)



Fig 35 Case XIII Roentgenogram showing failure of adequate compression of involved upper lobe, on account of dense adhesions

March, 1929, showed large cavities in the upper right lobe (Fig 30) An attempt to close these by pneumothorax was made, but broad bands of adhesions prevented (Fig 31) Such adhesions as these cannot be severed by burning The lung was allowed to expand, the cavity being larger than before (Fig 32), with atelectatic tissue in the base, resulting in displacement of the heart to the right This lung space was obliterated by thoracoplasty, with restoration of the patient to working capacity (Fig 33)

Case XIII This patient showed such extensive lung destruction on the right (Fig 34) that nothing except total obliteration of the right chest cavity could hold out any hope for success However, pneumothorax was tried (Fig 35), but adhesions showed the futility of this, and thoracoplasty was finally performed, with restoration of the patient to health (Fig 36)

These thirteen illustrative cases are shown mainly to demonstrate the value of roentgenologic observations, as the tuberculous patient travels the road, frequently long and hard, to the cure of his disease and a return to the normal activities of



Fig 36 Case XIII Condition after closure of cavities by thoracoplasty

life A peculiar characteristic of the disease is the hopeful outlook which is almost universal with these patients The combined judgment of more than one advisor in avoiding pitfalls and choosing right methods will be required if this hope is to



Fig 31 Case XII Condition after collapse by pneumothorax which was not successful in closing the apical cavity (a)



Fig 33 Case XII Condition (November, 1931) after thoracoplasty, showing hemithorax obliterated and cavities closed

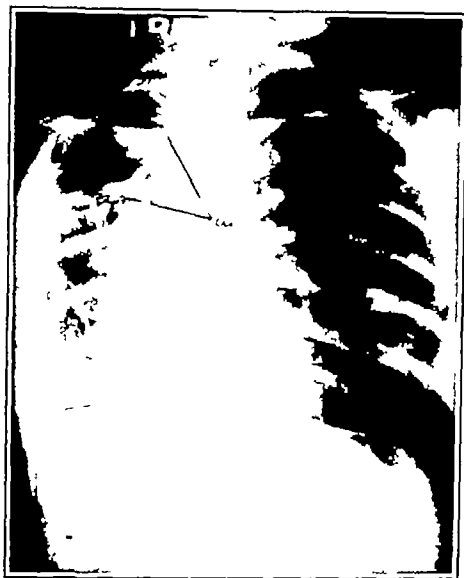


Fig 32 Case XII Condition after lung had expanded. Cavity still present (a) larger than before

compressed by extrapleural paraffin wax injection (Fig 26)

**Thoracoplasty**—This is the best known of radical surgical procedures for closing lung cavities. In times past, it has been looked upon as a desperate last resort, but should not be so regarded. It will fre-

quently succeed after the entire gamut of bed rest, postural rest, shot bags, pneumothorax, phrenicectomy, and pneumolysis has been tried and failed. Attempt should be made to evaluate the prospects of these methods and save the patient a long series of discouraging experiences, when it is evident that nothing except complete obliteration of the hemithorax can possibly succeed in restoring him to a useful state of health. The judicious clinician will not delay too long in seeking counsel of roentgenologist and surgeon, for determining whether or not simpler methods hold out any hope of success.

**Case XI** The roentgenogram made in June, 1930 (Fig 27), showed a very large double cavity occupying most of the upper two-thirds of the right lung. An attempt to close this double cavity by pneumothorax, supplemented by phrenicectomy, was made (Fig 28), and failed. Thoracoplasty was then performed (Fig 29). Immobility of the mediastinum prevented complete obliteration of the lung space on the involved side, leaving the cavity partly open. Later this was closed by extrapleural paraffin filling.

**Case XII** A roentgenogram made in

# A NEW ADAPTATION FOR CARDIAC MEASUREMENT OF THE FRONTAL SILHOUETTE<sup>1</sup>

By MAURICE RONA, M D , *New Brunswick, N J*, and WILLIAM G HERRMAN, M D ,  
F A C P , *Asbury Park, N J*

## A NEW METHOD OF MENSURATION OF THE POSTERO-ANTERIOR HEART A COMPARATIVE STUDY

WHETHER or not mensuration is justifiable at all is still a much argued question, dividing the roentgenologists into opposing camps, with the cardiologists mostly joining the opposition. Those who practise mensuration say that the diagnosis of heart diseases has been made from measurements and proved against the skepticism of the clinician by electrocardiography, time, and autopsy. Those who condemn the idea have nothing but scornful disdain for "mathematics in x-ray," and maintain that only the size, shape, and relation of the heart to adjacent organs comprise radiology's contribution to the study of heart disease. When we find such diametrically opposing views, we have to study the problem from the ground up.

*Review of the Literature*—A review of the literature shows that the idea of mensuration is gaining strength. The text-books of Assmann (1), Schinz (2), Holmes and Ruggles (3), and Kerley (5) give figures for the transverse diameter, the area of the P-A silhouette, and the methods for estimating the volume of the heart. Others, who compared the cardiac transverse diameter with the transverse diameter of the chest, cardio-thoracic ratio, and with the length diameter of the heart, are as follows: Dann (6), Fossier (7), Pendergrass (8), Chandlee and Burvill-Holmes (9), Miller and Gershon-Cohen (10), Dann (11), Steel (12), and White and Camp (13). Hodges (18), Hodges and Eyster (14), and Bedford (19) correlated the transverse diameter of the heart and the frontal area with the height, weight, and age of the

person. Also they worked out, on a purely mathematical basis, prediction formulas. All of these workers take only one diameter into account, but as the material has gathered, it becomes more and more evident that the transverse diameter is not a reliable guide to the diagnosis of the pathologic conditions. The frontal area, on the other hand, is rather difficult to measure because it gives rise to many errors. The main objection to these methods is that they do not give information about the individual chambers but consider the heart as a unit. However, this objection cannot be raised against the Vaquez-Bordet method (20), which gives measurements of the individual chambers and a table of the normal and pathologic averages. In this country, Levene and Reid (21) took up this method, which will be discussed more fully further on in this article, and made a rather thorough study of it.

Other investigators started out in another direction. Rigler (22, 24) relies on the fact that the left auricle is in close proximity to the esophagus, and an enlargement of the auricle must displace the esophagus. Therefore, he fills the esophagus with barium and takes films in the right lateral view, observing the curving and deviation of the barium column. Nichols and Ostrum (25) use the right oblique position. Neither Rigler nor Nichols and Ostrum use measurements.

Kane, Andrew, and Warren (26) struck out in still another direction. The study of mounted anatomic preparations showed them that, in the left oblique position, the interventricular septum is mid-way between the aorta and the pulmonary cone and can be marked with relative ease, making possible the separate measurement of the left and right ventricles.

Fray (27) further developed Kane's method, with some modifications. He

<sup>1</sup> Read before the Radiological Society of New Jersey, Feb 10, 1934. Accepted for publication April 9, 1934.

be realized. Happy is the patient whose course along this path is guided by the co-operative thinking of a tactful, sympathetic, and intelligent physician, a skillful and courageous surgeon, and a well-trained and competent roentgenologist.

The cases used as illustrations in this paper are from the private practices of Dr F G Holmes, Dr H S Randolph, and Dr V S Randolph, of Phoenix, Ariz., to whose courtesy the writer is indebted for clinical notes and data.

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scopically and serves as a landmark for the right ventricle. They, after Frick, differentiate between enlargement of the inflow and outflow tract. The latter is recognized on the P-A film by the prominence of the pulmonary cone, the former on the left oblique film by the following: (1) prominence of the right lower cardiac border, (2) angulation of the anterior cardiac border, (3) broadening of the diaphragmatic heart outline, (4) displacement of the interventricular groove to the left and upward. It is interesting to note that the point of their interventricular groove does not coincide with the constructed septum of Fray.

We shall not discuss further the methods that measure only the length and width of the heart, as these give no information of the individual chambers. We believe it is obvious that if a method can give such information, it is superior to the less exact methods. The Vaquez-Bordet method (Fig 1) takes the following measurements: *A-B* as the left ventricle, *D-A* as the right ventricle, *D-E* as the right auricle, *B-F* as the left auricle. Unquestionably all these chords bisect the respective chambers, yet their practical value is not always satisfactory because their direction is not coincident with the greatest enlargement of the chambers. For this reason the original figures of Vaquez and those of Levene show too great a variation and overlapping in health and disease. Fray's constructed septum and the anatomic septum are two different things. Therefore, the mensuration of the ventricles, based on this line, cannot be trustworthy.

These are some of the deficiencies in existing methods of radiographic cardiac mensuration that prompted us to search for a new way of attacking the problem, and to lay the diameters in a different fashion.

*Our New Method*—Starting from textbook drawings and Le Wald's experiments, we took the atrio-ventricular ostia into account and, because they remain centrally located, no matter how large the chambers become or in what direction they grow,

we fixed their position for a starting point in our measurements.

Our second consideration concerned the direction in which the individual chambers may grow in disease. We know that the left ventricle grows toward the apex, leftward and downward, the right ventricle may enlarge to the right and toward the diaphragm if the inflow tract is involved, upward and toward the pulmonary cone if the outflow tract dilates. The right auricle grows upward and toward the right. We speak of the left auricle last because it offers particular difficulties, it lies posteriorly and never shows on the P-A silhouette, and when enlarging it grows toward the right and backward. Therefore, any attempt to measure it on the P-A film seems to be futile, yet it can be measured indirectly as we shall show. The bulging on the left median border, so-called "mitral configuration," is caused by the enlargement of the outflow tract of the right ventricle. Therefore our "*L-A* diameter" measures the outflow tract of the right ventricle and not the left auricle. But we know that in mitral disease there is a compensatory enlargement of the right ventricle, the pulmonary cone becomes larger, the right ventricle forms part of the left border, and the left ventricle is pushed backward, thus having a lesser part in the left border formation. Consequently our point *B* (Fig 1) moves downward and the diameter *B-F* lengthens, a consequence by which we can infer that an enlargement of the left auricle has taken place.

*Technic of Our Method*—For the technic of constructing our diameters, we refer to Figure 1, which presupposes that the chest-cage is of normal shape and that the heart is normal in position and in normal rotation. *B* marks the left auriculo-ventricular, *E* the right auriculo-aortic, *D* the right auriculo-diaphragmatic point, and *A* the apex. *B-D* is the base-line which passes through both ostia. The tricuspid lies at the intersection of the base-line and the mid-line at *T*. We find the mitral opening in the following way: connect the left auriculo-ventricular point (*B*) with



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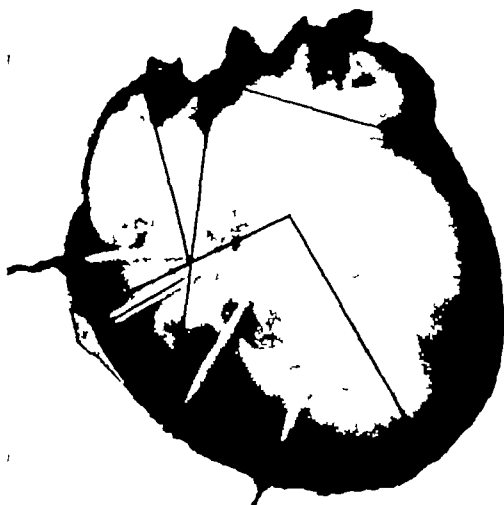


Fig 2

the right auriculo-aortic juncture (*E*) up to the mid-line (*F*), from here, that is, from the median end of the *L-A* chord, draw a connection to the apex, the intersection of these two lines thus locating the mitral valve (*M*). From the mitral valve to the apex *M-A*, we measure the left ventricle diameter, from the mitral opening to the right diaphragmatic point, the right ventricle (inflow tract). The distance between the tricuspid ostium and right auriculo-aortic juncture gives the right auricular diameter (*R-A*). We have previously mentioned the *L-A* chord and note that we called it the left auricular chord only for the sake of convention, but in reality it measures the outflow tract of the right ventricle.

In order to get any value at all from these measurements, it is necessary to fix the guiding points with the greatest care. If the positioning of the patient is accurate and there is no rotation, then the spinous processes and the trachea will fall in the mid-sternal line. The apex and the two auricular points are preferably observed and marked under the fluoroscope, when also note should be taken of whether or not the heart is normally or abnormally rotated. Abnormal rotation, naturally, excludes the possibility of reliable mensuration. The apex may be below or above the

diaphragm and should be marked without regard to the diaphragm. The left auriculo-ventricular point may present considerable difficulties, but the following observation may help. The juncture of the left ventricle with the left auricular appendage, or with the right ventricle, is usually marked by a small notch—the sulcus between the auricular appendage and the ventricle, or the sulcus of the transverse coronary vessels between the ventricles. In the absence of the notch, the left auricular appendage may still be border-forming and we will be able to find it by remembering that the appendage does not pulsate, consequently its shadow-line appears sharper and unblurred, while that of the pulmonary cone and the left ventricle is fuzzy or double-lined. This observation about the relative sharpness of the outline may hold good only for the customary slower technic and may not be applicable in the ultra-fast exposures. In other cases, when the right ventricle is enlarged but the left one is not, the bulging line of the right ventricle at the left border will fall down in a straight line toward the apex. The validity of the foregoing theoretical considerations had to be tested and proved by autopsy findings and by clinical observation.

*Autopsy Findings*—The first autopsy material came from a post-operative death of a subject with a normal heart. The heart was removed from the cadaver about twenty hours after death. We put the heart in a position approximating the normal as nearly as possible, then injected first one, then the other, auricle with sodium iodide solution and made exposures at a 6-foot distance. Figure 2 shows the chambers with the diameters drawn in, and also the fact that the diameters correspond very closely to their respective chambers. The second postmortem specimen was that of a man who had a syphilitic aortic lesion. X-rays had been taken of his heart during life. After making tracings *in situ*, we removed the heart and lungs together and fixed them in formalin. About six hours later, we injected both auricles with so-

dium iodide Figure 3 shows the result, while Figure 4 is a composite picture of the film made in the living, and of the tracing of the injected heart superimposed on the film. You see that our diameters coincide with their respective chambers, and the image of the living and the formalin-fixed heart correspond to each other. Also, Figure 5 shows a case in which the post-mortem corroborated the roentgen diagnosis of ventricular enlargements. The tracing *in situ* is superimposed on the film. Figure 6 did not come to autopsy, but the sudden death of the man from coronary thrombosis clinched the diagnosis. In this case the customary mensuration methods do not show any pathology, while our method proves that there was an enlargement of both ventricles.

*Clinical Study*—For clinical proof, there were two ways open for us. One was to find illustrations in books or magazines in which the normality or pathology of the case was definitely known, and in which, some measurements being given, we could reconstruct the other measurements and

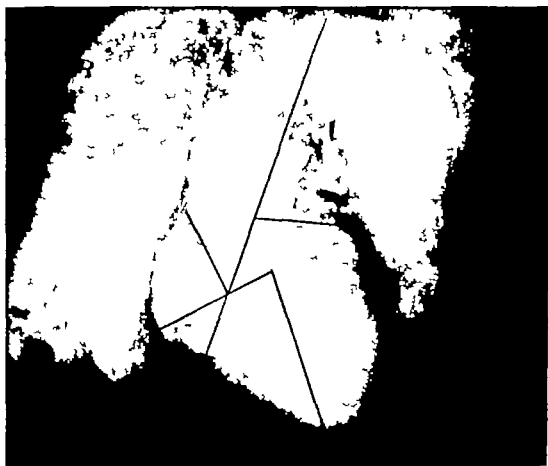


FIG 3

make a reasonable comparison with our own diameters. Luckily, we found such illustrations in Holmes and Ruggles' book, and in Dann's and in Levene's articles. The following are the results of the comparison. Dann's normal heart, although larger than what we regard as normal, had normal proportions and diameters, although again the *RV* diameter appeared a

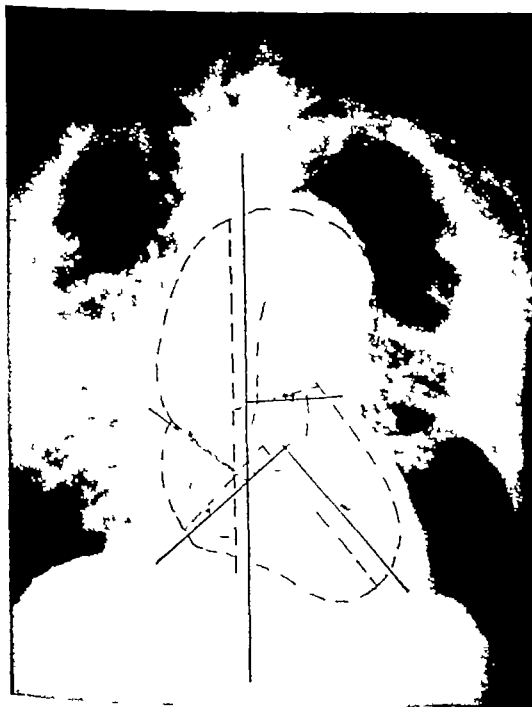


FIG 4

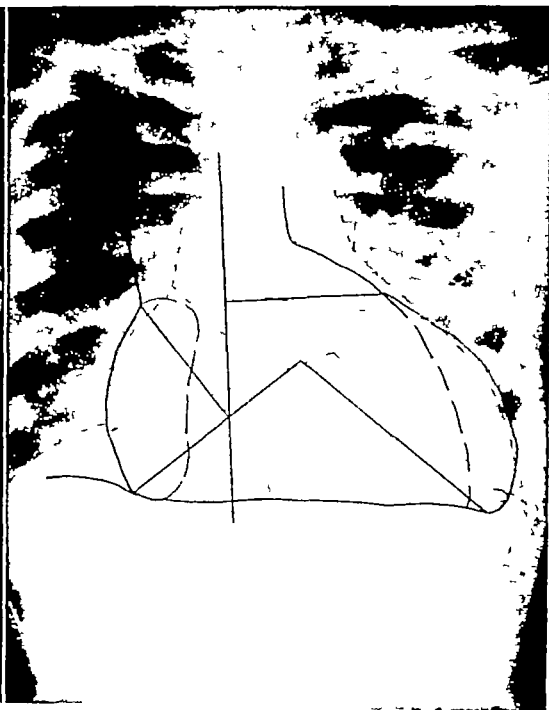


FIG 5

trifle too large. The "mitral stenosis" showed a predominance of our *RV* and *LA* diameters and a small *LV*, the "syphilitic aortic regurgitation" had large ventricular chords, the "hypertensive heart disease," a very markedly enlarged *LV*. And so, our measurements and expectations did not fail us. In Levene's article, we found ten illustrations in which the scale could be reconstructed. In his "mitral stenosis," our diameters indicate large auricles and a large right ventricle. In the "mitral insufficiency," both ventricles and the left auricle show enlargement with our measurements. In the "double mitral," in which he states that both ventricles and the left auricle should be larger, our measurements show both ventricles increased in size. The "aortic stenosis" and also the "aortic insufficiency" require large left ventricular and small auricular chords—our measurements give them. Levene also gives a case of sinus arrhythmia and a case of extra-systole, in which he finds no alteration of cardiac contour or size, yet our measurements show a large right ventricle in both instances. On Fray's illustrations, the drawing-in of our diameters checked up with his findings. There is one instance, however, which we want to mention specifically. Figure 9, in the February, 1932, issue of the "American Journal of Roentgenology and Radium Therapy" carries the diagnosis of slight left ventricle enlargement, with the remark that the cardiothoracic ratio is normal and cardiac enlargement would have been missed if reliance had been placed on the transverse diameter of this single view. Our diameters show in this case both ventricles above normal. These results encouraged us to gather clinical material to carry out measurements in controlled cases.

All of the films used for measurements were taken in an upright position, in deep inspiration, and at a target-film distance of five or six feet. We realize that the variable distance makes a difference in the size of the heart shadow, but actual measurements showed that the divergence is only about 3 per cent, which we do not consider

too great for practical purposes. Furthermore, the proportional measurement of the heart chambers remains constant at the various distances. Our scheme is based on this proportion.

*Analysis of Our Data*—In Table I, v

TABLE I—HEALTHY CASES (126) NEW METHOD MEASUREMENTS

Case No	LV	RV	LA	RA	Sum
1	49	44	44	40	177
2	52	50	44	41	187
3	56	50	49	45	200
5	52	56	47	65	220
N 6	58	57	43	63	221
N 7	68	49	49	55	221
8	55	55	57	55	222
N 9	65	62	41	55	223
10	71	62	40	50	223
N 11	70	57	52	45	224
N 12	61	60	42	61	224
N 13	65	58	45	57	225
14	75	66	37	47	225
N 15	60	46	53	67	226
N 16	74	55	50	47	226
N 17	69	58	46	55	228
N 18	69	59	48	53	229
19	70	54	49	56	229
21	72	61	46	50	229
23	72	45	57	56	230
24	65	55	53	57	230
N 25	73	70	42	46	231
N 26	69	64	44	54	231
N 27	60	56	57	58	231
28	66	59	47	59	231
N 29	70	60	54	49	233
30	71	52	48	62	233
N 32	65	68	44	53	235
N 34	68	65	50	53	236
35	66	65	49	56	236 <sup>1</sup>
36	62	64	46	65	237
38	69	61	50	57	237
N 39	62	67	52	57	238
40	61	61	52	61	238
41	63	60	55	60	238
42	75	60	53	50	238
43	64	66	54	54	238
44	78	63	50	48	239
45	62	68	53	56	239
N 46	69	65	53	53	240
N 47	62	63	53	62	240
48	74	54	54	58	240
49	75	61	51	53	240
N 50	72	70	44	55	241
N 51	78	70	46	47	241
52	65	63	50	63	241 <sup>1</sup>
N 54	72	69	46	55	242
55	75	69	42	57	243
56	72	63	56	52	243
57	66	69	60	48	243
N 58	74	68	49	54	243
59	70	57	57	59	243
N 61	74	69	43	58	244
63	62	57	60	65	244
66	69	67	49	60	245
N 67	88	68	40	50	246
N 68	71	72	43	60	246
N 69	65	66	50	65	246
N 70	70	65	52	53	246

Case No	LV	RV	LA	RA	Total
N 71	81	74	41	51	247
72	78	64	44	52	248
N 73	60	73	56	60	249
N 74	75	57	61	56	249
75	68	59	52	50	249
N 76	76	70	49	55	250
77	78	64	56	52	250
78	72	70	48	60	250
79	77	68	52	53	250
80	76	68	53	53	250
N 81	85	64	52	50	251
N 82	80	61	57	53	251
84	80	61	55	54	251
86	77	64	56	54	251 <sup>1</sup>
87	75	70	55	51	251
88	68	64	63	56	251
N 89	71	65	65	51	252
91	71	64	58	59	252
N 92	80	69	50	54	253
93	74	63	55	62	254
94	74	61	59	60	254
95	78	58	61	57	254
96	51	61	65	77	254 <sup>2</sup>
98	78	65	56	56	255
102	65	64	62	65	256
103	85	61	64	46	256
104	82	69	49	56	256
N 105	74	63	68	52	257
106	78	63	59	57	257
107	89	60	54	54	257 <sup>4</sup>
N 108	77	65	53	62	257
109	84	75	45	53	257
111	70	60	63	54	257
N 112	78	76	48	56	258
113	78	66	56	58	258
115	73	70	57	59	259
N 116	83	71	55	51	260
117	69	71	59	61	260
122	78	71	61	51	261
123	70	74	56	61	261
N 124	70	76	55	61	262
N 125	83	66	62	51	262
127	86	70	46	60	262
132	79	65	55	64	263
133	70	69	60	64	263
134	78	68	56	61	263
N 135	87	68	57	52	264
136	71	68	57	68	264
137	79	71	58	56	264
N 138	74	74	56	61	265
N 139	74	73	59	59	265
N 140	83	76	50	56	265
N 141	74	75	62	54	265
143	75	77	64	50	266
144	72	69	69	57	267
151	83	66	67	56	272
155	86	68	60	60	274
157	80	77	59	59	275
158	69	73	68	65	275
162	85	77	49	67	278 <sup>6</sup>
163	75	75	58	70	278 <sup>6</sup>
166	80	73	65	62	280
N 167	79	78	73	51	281 <sup>7</sup> (Ex)
169	83	71	63	64	281
N 176	83	76	65	62	286
177	88	75	57	68	288
N 179	80	77	71	61	289 <sup>7</sup> (In)

TABLE II —HEALTHY CASES (126) VAQUEZ-BORDET MEASUREMENTS

Case No	LV	RV	LA	RA	Total
1	52	72	43	43	210
2	52	79	43	47	221
3	52	81	49	51	233
5	58	80	43	71 <sup>8</sup>	252
6	65	80	40	75	260
7	76	82	40	65	269
8	58	82	52	68	260
9	80	81	40	77	278
10	82	88	40	65	275
11	75	95	51	58	299
12	74	80	35	88	277
13	68	93	38	69	268
14	81	98	37	58	274
15	74	70	47	76	267
16	79	95	50	50	283
17	75	101	42	65	283
18	77	89	47	67	280
19	78	90	47	64	279
21	79	95	46	65	285
23	85	84	54	65	288
24	68	92	50	61	271
25	80	101	42	65	288
26	77	90	42	70	279
27	80	77	55	71	283
28	80	82	45	75	282
29	75	99	53	60	287
30	86	80	46	76	288
32	76	89	44	76	285
34	72	98	50	66	286
35	76	91	49	72	288
36	75	86	43	82	286
38	84	85	49	72	290
39	76	87	52	76	291
40	67	91	50	72	280
41	72	88	53	71	284
42	78	102	51	61	292
43	66	100	52	66	284
44	82	106	50	59	297
45	72	84	51	68	275
46	69	106	51	62	288
47	72	87	50	78	287
48	85	87	53	70	295
49	87	93	51	66	297
50	80	98	43	76	297
51	92	101	46	68	307
52	77	88	48	77	290
54	89	91	46	80	306
55	78	104	40	57	279
56	76	102	55	64	297
57	58	116	59	51	284
58	86	91	44	73	294
59	82	89	56	69	296
61	87	97	40	80	304
63	66	90	55	75	286
66	83	91	48	77	299
67	98	100	38	72	308
68	77	97	40	80	294
69	75	88	47	82	292
70	82	110	52	57	301
71	90	106	41	71	308
72	79	114	44	69	308
73	61	104	54	60	279
74	86	98	61	67	314
75	75	94	52	59	280
76	86	110	45	70	311
77	77	114	55	63	309

<sup>1</sup> Nurse.<sup>2</sup> Same person, six months later<sup>3</sup> Films taken one and one-half years apart<sup>4</sup> Pathology in RA is possible<sup>5</sup> Films taken one week apart<sup>6</sup> Inspiration and expiration<sup>8</sup> Cases in italics are considered abnormal according to Vaquez

Case No	LV	RV	LA	RA	Total
78	86	91	48	79	306
79	87	99	52	71	309
80	82	106	53	68	309
81	91	109	52	63	315
82	90	100	57	66	333
84	86	105	55	67	313
86	89	100	55	71	315
87	75	113	55	65	308
88	68	100	60	62	290
89	74	105	62	73	314
91	83	95	57	74	309
92	83	110	49	73	315
93	83	98	53	78	312
94	89	94	57	75	315
95	74	110	59	58	301
96	53	85	51	80	269
98	78	112	55	68	313
102	75	93	61	76	315
103	77	122	64	54	317
104	86	112	48	70	316
105	78	118	66	62	324
108	83	100	51	78	312
106	90	102	59	68	319
107	92	114	51	64	321
109	92	111	45	74	322
111	75	97	61	65	298
113	89	120	56	74	339
112	80	115	48	72	315
115	78	108	56	70	312
116	84	120	53	68	325
117	77	112	57	67	313
122	77	121	61	62	321
123	77	105	55	76	313
124	76	105	52	80	313
125	87	114	62	65	328
127	95	102	45	78	320
132	89	101	53	76	319
133	78	102	57	75	312
134	77	116	54	66	313
135	91	118	57	64	330
136	82	95	54	84	315
137	79	117	57	68	319
138	80	102	51	83	316
139	75	113	53	75	316
140	87	116	44	74	321
141	80	113	62	70	325
143	70	127	64	58	319
144	68	122	67	70	327
151	86	116	65	67	334
155	93	112	59	73	337
157	81	118	57	75	321
158	74	109	64	76	323
162	94	105	47	90	336
163	89	100	56	90	335
166	98	106	59	79	342
167	66	134	73	62	335
169	96	119	63	77	355
176	86	122	64	77	349
177	91	122	56	73	342
179	84	125	68	78	355

The normals of Vaquez are

LV from 67 mm to 85 mm  
RV from 85 mm to 147 mm  
LA from 35 mm to 50 mm  
RA from 35 mm to 65 mm

arranged our measurements of 126 healthy persons. In Table II, same persons and same grouping, the Vaquez-Bordet measurements are given and all the figures that

fall outside the normals of Vaquez are marked. Notice how often these measurements transcend his normals in healthy and in hardworking persons. Part of the material in these tables is furnished by 50 healthy student nurses, marked in the table with an "N." This selected group was carefully checked clinically, easily kept under observation, and was available for check-up. In this sub-group of 50, the left ventricle appears larger than normal in 14 cases, the left auricle larger in 21 cases, and the right auricle larger in 36.

Our own diameters were arranged according to the sum of the individual diameters, which we claim may be used as an index of the size of the heart. Please note that the mean average of all of our diameters, mainly that of the ventricles, increases proportionately with the size of the heart, and, also, that the sum of the diameters is in correlation with the area of the hearts as expressed in square centimeters (see Table III)—a fact which could not be said of the Vaquez figures. We offer Table IV as proof that the area in square centimeters is predictable from the sum of the diameters, the error in prediction not being more than, in average, 10 or 15 per cent, which we estimate to be a rather good result, considering the difficulty of an accurate area measurement. Whether one uses a planimeter or a celluloid sheet ruled in square centimeters, counting squares and estimating fractions, the upper and the lower heart border has to be guessed, therefore, an accurate area measurement is impossible.

The figures given in Tables I and II are analyzed in Table V and in Chart I. The table compares the millimeter range and the mean average of the individual diameters in health and in disease. Each chamber is treated separately, the first line shows the normal figures, then are shown the four groups of pathologic findings. This table, together with the graphic presentation of Chart I, clearly demonstrates that the absolute length of the diameters is dependent on the size of the heart. Therefore, it is not enough, as it is now custo-

mary, to state the length of a diameter it is also necessary to give the size of the heart in which it is found. Our method makes that reference rather easy simply give the sum of the individual diameters. For instance, a left ventricular chord of 86 mm may be normal in a heart of me-

dium size of a sum of 260, but it will have to be regarded as pathologic, or at least on the borderline of pathologic, in a small heart of a sum of 230. Chart I is not only a graphic presentation of the data of the foregoing table, but also a comparison of the Vaquez method with ours. The interrupted lines

TABLE III—SHOWING RELATION OF FRONTAL AREA TO THE SUM OF DIAMETERS

Area (sq cm)	Number of cases in groups of the sum of diameters												
	220- 229	230- 239	240- 249	250- 259	260- 269	270- 279	280- 289	290- 299	300- 309	310- 319	320- 329	330- 339	460- 469
65-69	3												
70-79	12	3	3										
80-89		13	19	5									
90-99		1	4	22	12		2						
100-109			2	4	12	5	2						
110-119						6	7	3					
120-129						1	1	3	3				
130-139								3	2	3			
140-149								1	1		2	1	
150-159										2			
160-169												1	
170-179													
180-189												1	
240-249													2

TABLE IV—AREA (SQ CM) PREDICTED FROM THE SUM OF THE DIAMETERS

Case No	Total	Predicted	Measured (area)	Error	Case no	Total	Predicted	Measured (area)	Error
21	229	76-82	79	±3	144	267	104	103	-1
23	230	80	79	-1	146	268	108	106	-2
28	231	82	84	+2	150	271	104	115	11
30	233	84	82	-2	151	272	108	114	6
42	238	84	86	+2	152	273	100-120	127	7, 27*
44	239	86	90	+4	153	273	110	102	-8
48	240	82	83	1	155	274	108	114	6
50	243	84	89	5	156	274	114	116	2
57	243	84	81	-3	157	275	108	109	1
59	243	82	90	8	160	277	108	119	11
60	243	80	78	-2	168	281	104	108	8
75	249	90	89	-1	180	289	112	112	0
78	250	90	89	-1	181	289	120	127	7
85	251	90	96	4	184	291	115	126	11
87	251	94	95	1	182	290	114	119	5
91	252	90	96	6	185	293	120	128	8
93	254	86-94	91	-5	186	294	120	126	6
94	254	90	98	8	187	294	124	139	15
98	255	90	85	-5	188	294	126	143	17
99	255	95	93	-2	189	296	125	131	6
109	257	98	105	7	191	298	122	133	11
110	257	95	100	11	192	299	115-125	112	-3, 13
113	258	98	104	6	194	303	126	134	8
121	261	94-104	103	-1, 9	195	303	134	148	14
122	261	100	109	9	201	311	126	152	26
127	262	98	94	-4	203	315	135	139	4
129	262	78-84	96	18, 12	206	319	150	153	3
130	263	100	104	4	211	339	155	169	14
132	263	100	109	9	219	460	230	242	12
143	266	102	105	3					

\* This is the greatest error 21 per cent.

Case No	LV	RV	LA	RA	Total
78	86	91	48	79	306
79	87	99	52	71	309
80	82	106	53	68	309
81	91	100	52	63	315
82	90	100	57	66	313
84	86	105	55	67	313
86	89	100	55	71	315
87	75	113	55	65	308
88	68	100	60	62	290
89	74	105	62	73	314
91	83	95	57	74	309
92	83	110	49	73	315
93	83	98	53	78	312
94	89	94	57	75	315
95	74	110	59	58	301
96	53	85	51	80	269
98	78	112	55	68	313
102	75	93	61	76	315
103	77	122	64	54	317
104	86	112	48	70	316
105	78	118	66	62	324
108	83	100	51	78	312
106	90	102	59	68	319
107	92	114	51	64	321
109	92	111	45	74	322
111	75	97	61	65	298
113	89	120	56	74	339
112	80	115	48	72	315
115	78	108	56	70	312
116	84	120	53	68	325
117	77	112	57	67	313
122	77	121	61	62	321
123	77	105	55	76	313
124	76	105	52	80	313
125	87	114	62	65	328
127	95	102	45	78	320
132	89	101	53	76	319
133	78	102	57	75	312
134	77	116	54	66	313
135	91	118	57	64	330
136	82	95	54	84	315
137	79	117	57	66	319
138	80	102	51	83	316
139	75	113	53	75	316
140	87	116	44	74	321
141	80	113	62	70	325
143	70	127	64	58	319
144	68	122	67	70	327
151	86	116	65	67	334
155	93	112	59	73	337
157	81	118	57	75	321
158	74	109	64	76	323
162	94	105	47	90	336
163	89	100	56	90	335
166	98	106	59	79	342
167	66	134	73	62	335
169	96	119	63	77	355
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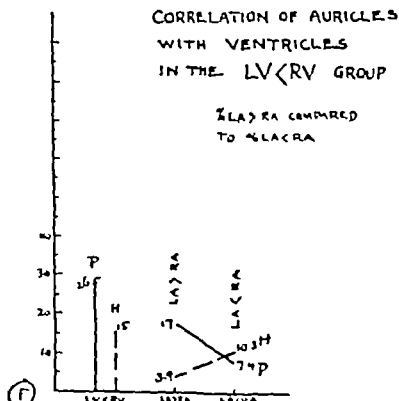
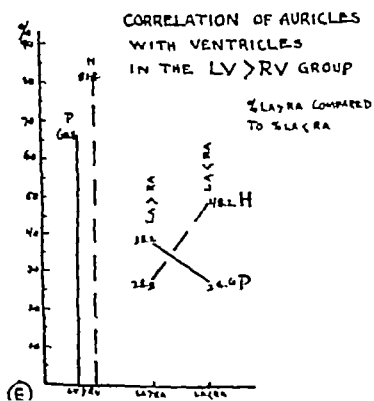
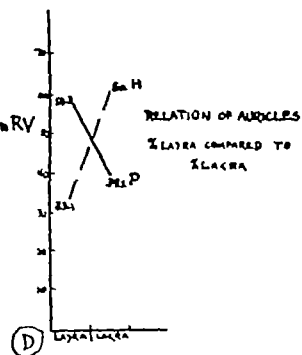
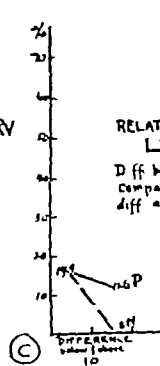
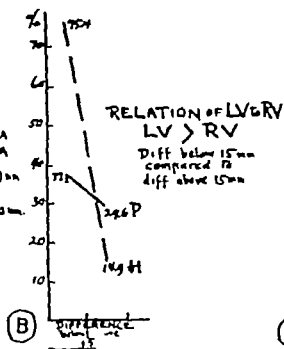
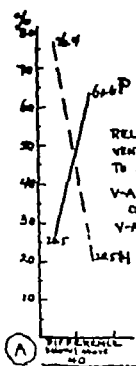
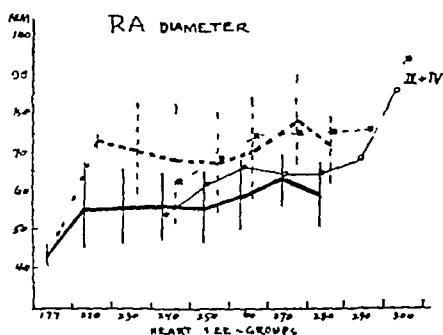
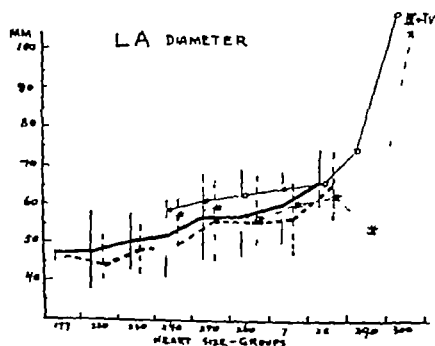
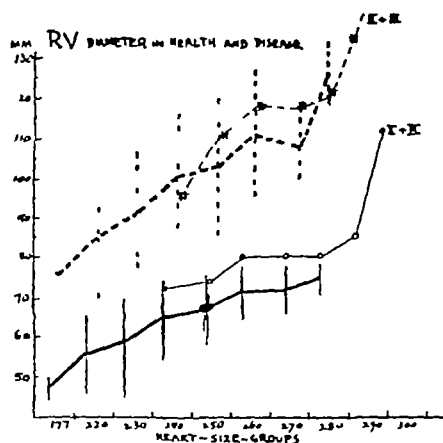
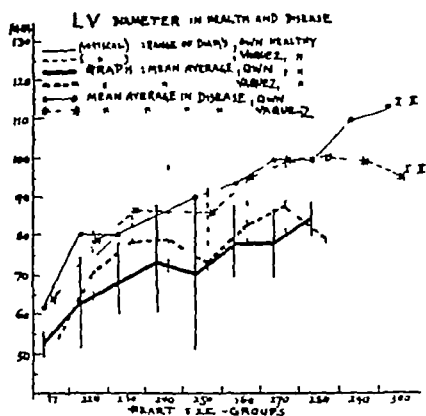
LV	from 67 mm to 85 mm
RV	from 85 mm to 147 mm
LA	from 35 mm to 50 mm
RA	from 35 mm to 65 mm

arranged our measurements of 126 healthy persons. In Table II, same persons and same grouping, the Vaquez-Bordet measurements are given and all the figures that

fall outside the normals of Vaquez are marked. Notice how often these measurements transcend his normals in healthy and in hardworking persons. Part of the material in these tables is furnished by 50 healthy student nurses, marked in the table with an "N". This selected group was carefully checked clinically, easily kept under observation, and was available for check-up. In this sub-group of 50, the left ventricle appears larger than normal in 14 cases, the left auricle larger in 21 cases, and the right auricle larger in 36.

Our own diameters were arranged according to the sum of the individual diameters, which we claim may be used as an index of the size of the heart. Please note that the mean average of all of our diameters, mainly that of the ventricles, increases proportionately with the size of the heart, and, also, that the sum of the diameters is in correlation with the area of the hearts as expressed in square centimeters (see Table III)—a fact which could not be said of the Vaquez figures. We offer Table IV as proof that the area in square centimeters is predictable from the sum of the diameters, the error in prediction not being more than, in average, 10 or 15 per cent, which we estimate to be a rather good result, considering the difficulty of an accurate area measurement. Whether one uses a planimeter or a celluloid sheet ruled in square centimeters, counting squares and estimating fractions, the upper and the lower heart border has to be guessed, therefore, an accurate area measurement is impossible.

The figures given in Tables I and II are analyzed in Table V and in Chart I. The table compares the millimeter range and the mean average of the individual diameters in health and in disease. Each chamber is treated separately, the first line shows the normal figures, then are shown the four groups of pathologic findings. This table, together with the graphic presentation of Chart I, clearly demonstrates that the absolute length of the diameters is dependent on the size of the heart. Therefore, it is not enough, as it is now custo-





show the Vaquez measurements. This chart demonstrates at a glance that our figures show sufficient clearance between health and disease, but, on the other hand, we cannot find a guiding rule from the Vaquez curves.

We divided the pathologic cases into four groups, comprising not only the clearly

pathologic but also the suspected ones, according to the outstanding enlargement of the individual chambers.

In Group I, only the LV is large—26 cases  
 In Group II, LV and RV are large—26 cases  
 In Group III, only the RV is large—28 cases  
 In Group IV, some auric diam is large—14 cases  
 Thus we find large LV in 52 cases, 55 per cent  
 large RV in 54 cases, 57 per cent  
 large LA in 7 cases, 7 per cent

TABLE V—COMPARATIVE TABLE OF DIAMETERS IN HEALTH AND DISEASE  
 NEW METHOD MEASUREMENTS

Diameters and groups	Heart size groups									
	177-219	220-229	230-239	240-249	250-259	260-269	270-279	280-289	290-299	300-up
Left ventricle										
Normal	range 49-56 mean 52	52-75 63	60-78 69	60-88 74	51-89 70	69-87 78	69-86 76	79-88 83		
I	range 62 mean	79-80 79	79-83 81		86-90 88	84-105 94	88-110 99	96-100 98	92-95 94	96-107 101
II	range mean				100	85	89	92-94 93	91-108 99	92-134 113
III	range mean			72	53-66 59	75-85 80	65-82 73	74-85 79	83-88 85	64-88 76
IV	range mean			60-71 65	59-85 72	49-80 64		77	75-87 81	86
Right ventricle										
Normal	range 44-50 mean 47	46-66 56	45-70 57	54-74 64	58-76 67	65-77 71	66-77 71	71-78 74		
I	range 57 mean	62-68 65	56-68 62		62-69 65	61-75 68	62-77 69	67-75 71	68-77 72	74-75 74
II	range mean				81	73	84	82	81-89 85	81-105 93
III	range mean			72	72-74 73	77-84 80	78-83 80	74-84 79	83-89 86	82-143 112
IV	range mean			63-72 67	64-73 68	64-72 68		67	67-77 72	77
Left auricle										
Normal	range 44-49 mean 46	37-57 47	42-57 49	40-61 50	45-68 56	46-69 57	49-68 58	56-73 64		
I	range 53 mean	40-46 43	37-57 47		52-61 56	40-68 54	49-60 54	60-64 62	61-68 64	68-80 74
II	range mean				34	50	51	42-53 47	47-71 59	45-87 66
III	range mean			42	50-73 61	44-55 49	53-70 61	53-75 64	45-63 54	76-142 109
IV	range mean			55-62 58	52-70 61	52-74 63		75	67-79 73	75
Right auricle										
Normal	range 40-46 mean 43	45-67 56	46-65 55	47-65 56	46-65 55	50-68 59	50-70 63	51-68 59		
I	range 41 mean	41-42 41	38-53 45		44-44 44	42-53 47	42-60 51	53-58 55	60-69 64	54-65 59
II	range mean				40	52	53	55-67 61	53-60 56	54-71 62
III	range mean			55	60-65 62	51-60 55	54-75 64	52-75 63	61-76 68	68-103 85
IV	range mean			46-60 53	41-61 51	57-75 66		70	68-79 73	75

II the enlarged left ventricle diminishes the size of the left auricle on the frontal film (left auricle outflow tract of the right ventricle)

We also found a constant relationship of the left ventricle and the right auricle diameters. This relationship is chiefly affected by the height of the diaphragm, at least in drop-hearts. We see from Table VII that in drop-hearts we may expect a

large right auricle together with a small left ventricle and right ventricle, but when the diaphragm is high this ratio is reversed and we find a relatively large left ventricle and right ventricle with a small right auricle

*Testing Our Method*—In order to test the reliability of our measurements we compared the diameters in hearts x-rayed on two different occasions and give the figures

TABLE VI —PATHOLOGICAL CASES (94) NEW METHOD MEASUREMENTS

Case No	Group I (LV pathol )					Case No	Group II (LV and RV pathol )				
	LV	RV	LA	RA	Total		LV	RV	LA	RA	Total
4	62	57	53	41	213	97	100	81	34	40	255
20	80	68	40	41	229	119	85	73	50	52	260
22	79	62	46	42	229	160	89	84	51	53	277
31	83	56	57	38	234	172	92	82	53	55	282
33	79	68	46	42	235	174	94	82	42	67	285
37	79	68	37	53	237						
						185	91	82	67	53	293
85	86	69	52	44	251	186	99	89	48	58	294
101	90	65	57	44	256	187	98	82	54	60	294
110	90	62	61	44	257	188	108	84	47	55	294
118	92	70	51	47	260	193	94	81	71	53	299
121	90	61	68	42	261						
129	84	69	56	53	262	195	101	91	49	63	303
126	94	75	46	47	262	196	100	98	53	54	305
130	105	72	40	46	263	197	92	85	72	56	305
148	87	74	49	60	270	199	115	92	45	55	307
150	88	74	56	53	271	201	107	91	53	60	311
152	91	73	54	55	273	202	102	87	62	60	311
154	96	77	50	51	274	203	100	81	78	56	315
156	110	62	60	42	274	207	99	94	68	62	323
173	100	67	64	53	284	208	111	83	72	57	323
181	96	75	60	58	289	209	94	82	81	70	327
						210	105	95	70	64	334
184	95	73	61	62	291	211	113	81	81	64	339
189	92	68	67	69	296	212	106	104	74	60	344
190	92	77	68	60	297	214	110	98	78	71	357
194	96	74	68	65	303	215	115	100	87	65	367
204	107	75	80	54	316	216	134	105	73	68	380
	Group III (RV pathol )					213	64	98	92	92	346
53	72	72	42	55	241	217	85	106	103	87	381
100	66	74	50	65	255	218	86	113	122	76	397
114	53	72	73	60	258	219	79	136	142	103	460
131	82	77	44	60	263	220	81	143	135	102	461
146	85	77	49	55	268						
142	75	78	55	58	266						
147	84	84	49	51	268						
149	82	78	57	54	271						
153	65	83	70	55	273						
159	69	80	70	57	276	60	60	63	60	60	243
161	79	81	53	65	278	62	63	67	62	52	244
164	69	82	53	75	279	64	71	71	57	46	245
165	78	78	57	67	280	65	67	72	55	51	245
168	75	81	68	57	281						
170	79	80	71	52	282	83	85	73	52	41	251
171	85	84	53	60	282	90	59	67	68	58	2

But since the left auricle indicates enlargement of the outflow tract of the right ventricle, we are justified in adding these to the right ventricle group, getting thereby a total of 64 per cent for right ventricle pathology. Of paramount importance is the question of whether or not there is a constant relationship between the individual diameters, and whether or not pathologic conditions disturb that relationship. Let us first examine the relation of the ventricular area to the auricular area. We find that in health as well as in disease the ventricles are larger than the auricles; this was to be expected. However, we get another picture if we inquire into the size-differences of the ventricles and auricles. Taking size-differences below and above 40 as our base for comparison, we find (see *A* in Chart II)

	Normal	Pathol
Both $\downarrow$ larger than both <i>A</i> by not more than 39	76 4 per cent	26 5 per cent
Both $\downarrow$ larger than both <i>A</i> by more than 40	20 5 per cent	63 6 per cent

This means that small size-differences predominate in health but large size-differences are found only in disease.

Relation of the left ventricle to the right ventricle is expressed in the following figures

	Normal	Pathol
LV larger than RV	82 2 per cent	68 8 per cent
LV equals RV	2 4 per cent	6 4 per cent
LV smaller than RV	15 0 per cent	26 5 per cent

Normally, the left ventricle predominates over the right ventricle, while in pathology, there are almost twice as many cases having the right ventricle larger than the left ventricle. A more detailed analysis as to how much larger the diameters may be without disturbing the normal relations gives the following interesting data

	Normal	Pathol
LV larger than RV by less than 15 mm	75 4 per cent	37 2 per cent
LV larger than RV by more than 16 mm	14 9 per cent	29 6 per cent
LV smaller than RV by less than 10 mm	14 9 per cent	14 9 per cent
LV smaller than RV by more than 11 mm	0 8 per cent	11 6 per cent

It is evident that health and disease show opposite trends; compare also *B* and *C* on Chart II.

Coming now to the auricular diameters, we see in *D* of Chart II that in health the left auricle is smaller than the right auricle, but, in disease, the opposite holds true.

As to the correlation of the auricles with the ventricles, again comparing the number (percentage) of cases, having the left auricle larger than the right auricle, with the number (percentage) having the left auricle smaller than the right auricle first in that ventricular group in which the left ventricle is the larger diameter, and then in the other group in which the left ventricle is the smaller diameter, we may demonstrate in *E* and *F* on Chart II the clearly opposite tendencies in health and disease expressed in the crossing of the respective lines. Moreover, we may note that pathologic conditions tend to enlarge the left auricle diameter even if the left ventricle predominates over the right ventricle; this tendency is more marked if the right ventricle is larger than the left one. We may say, therefore, that pathology in the right ventricle (inflow tract) goes together with pathology in the left auricle (outflow tract).

We return now to Table V and Chart I which compare the range and the mean average of each diameter in normal and pathologic conditions. We must recall that Groups I and II show the left ventricle enlargement, Groups II and III show right ventricle enlargement. Keeping this in mind, we find the differences between the normal and pathologic satisfactory. The left ventricle mean is large in Groups I and II, but it is smaller than the normal in Group III, which means that the right ventricle pathology diminishes the length of the left ventricle diameter. This agrees excellently with our pathologic experiences which show that a hypertrophied right ventricle rotates the heart and pushes the left ventricle backward, crowding it out of the frontal silhouette. This fact is also borne out by the left auricle figures which are smaller than normal in Groups I and

TABLE IX—AREA (SQ CM) AND TRANSVERSE DIAMETER (MM) ACCORDING TO THE HODGES AND EYSTER FORMULA COMPARED WITH ACTUAL MEASUREMENTS

No	Sq cm area		Transverse		Diff ± mm
	Pre- dict	Found	Pre- dict	Found	
6	89 4	68	101?	92	- 9
7	89 3	68	102?	90	-12
9	91	76	98?	100	+ 2
11	90 4	72	104?	107	+ 3
12	92 7	75	100?	97	- 3
13	92 5	70	114	96	-18
15	88 6	72	104?	89	-15
16	94 3	74	118	103	-15
17	85 8	78	110	102	- 8
18	87 9	79	110	101	- 9
25	89 7	81	110	106	- 4
26	98 4	79	115	94	-21
27	90 9	84	105	101	- 4
29	89 8	80	112	110	- 2
32	98 5	77	110	103	- 7
34	88	82	108	104	- 4
39	100 2	84	110	102	- 8
46	97 6	80	111	106	- 5
47	85 4	81	109	101	- 8
50	—	85	—	117	
51	93 4	87	109	109	0
54	89 7	90	104	107	+ 3
58	88 4	86	113	103	-10
61	92 5	89	114	113	- 1
67	92 2	100	109	120	+11
68	90 8	84	110	105	- 5
69	90 2	83	106	109	+ 3
70	97 8	87	124	116	- 8
71	92 2	100	125	139	+14
73	96	88	114	115	+ 1
74	105 5	88	116	104	-12
76	96 2	92	112	115	+ 3
81	97	94	128	126	- 2
82	99	96	119	111	- 8
89	91 6	91	104	114	+10
92	99 6	92	116	120	+ 4
105	94 8	90	113	112	- 1
108	95 2	90	109	109	0
112	111 6	98	131	121	-10
116	91 5	93	112	126	+14
124	103 6	96	118	123	+ 5
125	86 4	98	116	109	- 7
135	102 6	100	127	121	- 6
138	100 5	95	115	122	+ 7
139	99 7	92	111	125	+14
140	96 2	100	112	127	+15
141	94 1	103	111	125	+14
167	97 4	95	108	136	+28
176	108 2	110	122	126	+ 4
179	97 4	110	108	145	+37

variation of the left ventricle diameter, and thought we might improve on the method. Later on, other methods were studied.

The prediction formulas of Hodges and Eyster, especially that for the frontal area, seem to be workable, but they contain many sources of error because the correlation of the heart with other body characteristics is inconstant. "The heart type is not in harmony with the subject's general anthropometric type. It is impossible to deduce cardiovascular behavior directly from the external morphologic type of constitution" (Pende Constitutional Inadequacies Lea & Febiger, 1928, p 61). The cardiothoracic ratio has been proven unreliable.

Rigler's method of showing the displacement of the esophagus by the enlarged left auricle is valuable, as is the method of Nichols and Ostrum, who utilize for the same purpose the right oblique position. Neither method is standardized although it may be and should be resorted to when information on the left auricle itself is needed.

Fray's method gives a fairly good idea of the relative sizes of the ventricles, but due to the difficulties in locating their "septum line," the ventricle measurements are a bit changeable. Neither will this position show the relation of the left auricle to the esophagus. A common objection against these methods is that they require a second posture (lateral or oblique) as a routine measure, and thus must be an exact posture.

Our own method, we think, shows possibilities. It demonstrates unquestionably the enlargement of the ventricles, and it is the first method to differentiate between inflow and outflow tract pathology of the right ventricle on the frontal plane without making additional films. Furthermore, we offer means whereby the cumbersome and unreliable area measurement can be done away with and supplemented by a figure at which it is easy to arrive. To our knowledge, we are the first to take the atrio-ventricular ostia into account when measuring the individual chambers on the

are similar. But we claim our method to be superior since it can be used in nearly any good *P-A* film with no specific radiographic technic.

*Comment*—When we originally started our investigations we had the Vaquez method only in mind. We saw the unexplainable discrepancies of the left and right auricle diameters, the insufficient

TABLE VII—COMPARISON OF DIAMETERS IN DROP-HEARTS (LOW DIAPHRAGM) AND PUSHED-UP HEARTS (HIGH DIAPHRAGM) NEW METHOD MEASUREMENTS

Diameter	Range and mean of diameters in size-groups in low and high diaphragms					
	220-229		230-239		240-249	
	Low diaphr (drop-hrt)	High diaphr	Low diaphr (drop-hrt)	High diaphr	Low diaphr (drop-hrt)	High diaphr
LV	52-70 61	69-74 71.5	60-72 66	68-73 70.5	62-74 68	60-78 69
RV	46-60 51	55-59 57	45-68 56	60-70 65	54-69 61	57-73 65
LA	42-53 47.5	48-50 49	46-57 51.5	42-54 48	46-60 53	42-61 51.5
RA	55-67 61	47-53 50	56-65 60.5	46-53 49	55-65 60	47-65 56

TABLE VIII—MEASUREMENTS IN HEARTS RADIATED ON TWO DIFFERENT OCCASIONS  
NEW METHOD MEASUREMENTS

No	LV	RV	LA	RA	Total	Sq cm	Transv	
35	66	65	49	56	236	81	103 mm	Second exposure 6 months later, heart larger, increase may be expected
86	77	64	56	54	251	93	114	
52	65	63	50	63	241	84	103	Second exposure almost two years later, patient had pneumothorax, high right diaphr, larger heart
107	89	60	54	54	257	100	114	
137a	79	61	56	61	257	90	116	Second exposure two and one-half months later right diaphr higher, right auriculo-diaphr point uncertain
137	79	71	58	56	264	102	120	
162	85	77	49	67	278	117	130	Second exposure 2 weeks later there is a slight difference in the absolute size and in position of heart
163	75	75	58	70	278	120	138	
167	79	78	73	51	281	95	145 (insp)	Shows effect of height of diaphr on position and diameters
179	80	77	71	61	289	110	136 (expir)	
199	115	92	45	55	307	148	157	Second exposure 2 weeks later Mitral disease decompensated
202	102	87	62	60	311	148	163	
165	78	78	57	67	280	130	108	Second exposure 4 months later incipient decompensation
153	65	83	70	55	273	102	142	
213	64	98	92	92	346	155	154	Second exposure 5 months later decompensated mitral
217	85	106	103	87	381	185	182	

The greatest difference between the measurements of the same diameter amounts to 16 per cent (in the LV of Nos 35 and 86, and in the RV of Nos 137 and 137a) but both measurements remain within the normal limit.

In the lower three pathologic cases, the change in the length of the diameters is explained by the change in the size of the heart but the second radiation, too, shows the respective pathology

in Table VIII. We make the following deductions: the greatest differences do not amount to more than 16 per cent and even then they remain within the normal limit, or show the same pathology, respectively.

A comparison of our radiologic findings with the clinical diagnosis gives the following results. In Groups I and II, left ventricle enlargement, the clinician diagnosed aortic lesion in 57.5 per cent of the diagnosed heart cases, and mitral disease in 20 per cent of the cases, while in Group III, right ventricle enlargement, aortic lesion

was claimed in 41 per cent only and mitral in 30 per cent. We also compared our method with that of Hodges and Byster. In Table IX the predicted and measured area and transverse diameter of 50 healthy student nurses are tabulated, however, the variation is too wide, and in some cases it would even indicate pathology, although clinically none of the girls showed any evidence of cardiac disease. In a few cases we were able to compare our measurements with figures according to the Fray method. The results, as can be seen from Table X,

TABLE A.—COMPARISON OF DIFFERENT METHODS OF MEASUREMENT

No	Pathology found in diameters of			Area		Transverse		Cardio-thorac
	Own	Vaquez	Fray	Predic	Found	Predic	Found	
53	RV	RA	RV	92 2	88	106	122	Normal
80	Normal	LA, RA	Normal	101	82	—	122	Normal
96	RA	LA, RA	RV	—	—	—	—	Normal
158	Normal	LA, RA	RV	—	—	—	—	Normal
175	RV	LV, LA, RA	Normal	—	—	—	120	Normal
193	LV, RV	LV, LA, RA	LV	106 4	136	130	150	Path
199	LV, RV	LV, RV, RA	LV, RV	103	148	125	157	Path
217	RV, LA, RA	RV, LA, RA	LV, RV	104	185	114	82	Path

frontal plane without making additional films

3 The method shows a reliable correlation of the various diameters to each other and to the size of the heart

4 The method makes the cumbersome and unreliable frontal area measurement superfluous, and supplements it with figures at which it is easy to arrive

5 The range and the mean average of our diameters show a characteristic change in, and according to, the pathology of the ventricles

6 Normally the left ventricle is the longest diameter, but if the right ventricle is longer, be suspicious of pathology

7 Normally the right auricle is longer than the left auricle, pathologic conditions tend to enlarge the left auricle, pathology in the right ventricle (inflow tract) goes together with pathology in the left auricle (outflow tract)

8 Comparison shows the value of our method against other methods

We wish to express our thanks to the Middlesex General Hospital and to Dr P S Avery for permission to use some of their material

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frontal plane, claiming that the ostia are the logical starting points, since they remain centrally located regardless of how large the chambers may become or in what direction they grow. We also claim that our diameters are laid in the direction of

think that the method itself is workable and worth studying

#### CONCLUSIONS

1 A study of 126 healthy and 94 pathologic, a total of 220, hearts was made

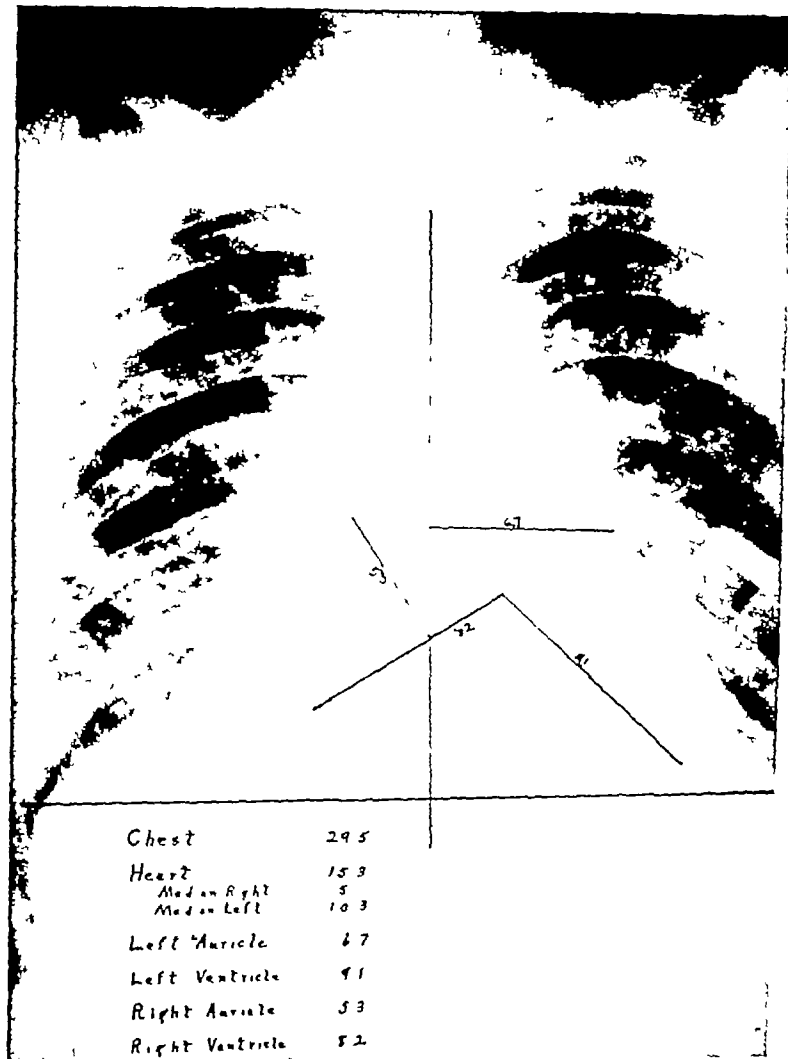


FIG 6

the greatest pathologic enlargement of the chambers. To our knowledge, we are the first who take into account the proportions of the chambers from one to the other, and to the size of the heart. We realize that there is room for further improvement, but we

and a new method of mensuration in the frontal plane is presented

2 The method demonstrates the enlargement of either or both ventricles, it is the first method to differentiate between inflow and outflow tract pathology on the

# MORE ON X-RAY PROTECTION STANDARDS<sup>1</sup>

By A. MUTSCHELLER, PH D, *New York City*

THE earliest injuries resulting from over-exposure to x-rays were mostly of a superficial nature and usually they were described as roentgen dermatitis. Most of these injuries were caused when x-ray tubes were tested with hand fluoroscopes and with the free bare hand as a test object, or they resulted from prolonged fluoroscopic examinations and accidental over-exposures when x-rays were applied for therapeutic purposes. Injuries of this kind are usually not accompanied by very extensive changes of the internal organs and of the blood, and in all probability, the immediate causes of radiation injuries to the surface of the skin from over-exposure, especially to non-filtered rays, have in recent years been practically avoided. (1) Thus protection against soft rays is brought about mostly by educational accomplishments which now induce operators to protect themselves by avoiding over-exposures to the soft rays that are absorbed in the superficial layers of the skin and which cause roentgen dermatitis.

However, in more recent times we have seen forceful evidence of a growing danger of injuries resulting from over-exposures to x-rays in particular such as are due to the accumulative character of doses and which are found to lead to the development of anemia, blood changes, uncontrolled cell growth, etc. These injuries to internal organs are mostly caused by well-filtered rays of higher penetrative power.

We can, therefore, recognize two periods and two types of roentgen injuries: the first, due to over-exposure to soft or non-filtered rays, and the second, caused by highly penetrating and unusually highly filtered rays. Of these, the first have now practically disappeared and are, therefore,

no longer an important subject for discussion, but the status of the injuries caused by the more highly penetrating radiations on the internal organs is quite different in many respects. For instance, because of the great length of time required for the accumulation of injurious doses, and the long latent period following the application of hard rays before the resulting changes are positively recognized, it happens that in many cases internal roentgen injuries are either overlooked or are recognized only when they have already become fatal. For such reasons, therefore, it seems that the number of internal roentgen injuries is in all probability larger than is usually assumed and admitted.

Facing these facts and finding that some apparently erroneous conclusions regarding protective standards have appeared in the literature (2), it would seem justified to review the subject, especially on the internal injuries in their relation to the present-day accepted safety rules.

*The Problem*—Undoubtedly the most important experimental work leading to the establishment of the present safety rules, which are accepted and adopted by the Committees in various countries, is that of Glocker and his associates (3), Behnken (4), and van der Tuuk and Boldingh (5). These authors have measured the radiation doses that are transmitted through various thicknesses of lead and other protective substances, and have recommended lead thicknesses for protective screens for use against radiations produced by various voltages. As a unit or tolerance dose, they accepted the measurements made by the present author in long established laboratories, which results have been corroborated since then in other ways (6). The radiation tolerance dose measured, and as originally proposed, is  $1/100$  part of a skin tolerance

<sup>1</sup> Read before the Radiological Society of North America, at the Eighteenth Annual Meeting at Atlantic City, Nov. 28-Dec. 1, 1932.



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dose per month (6) According to our present knowledge, this dose is absolutely safe for continuous toleration by normal healthy individuals, provided that certain specified hygienic and recreational rules are followed From the physical point of view, therefore, it would seem that these measurements and the results embodied in the safety protective rules are sound and that they can be unhesitatingly recommended But there are now further facts regarding the rays of higher penetrative power which have become known through therapeutic application of  $\gamma$ -rays, and these facts give rise to new aspects

In the first place, we now have the definite conclusion from observations and experience in radiation therapy that  $\gamma$ -rays of various wave lengths act differently upon human tissues, and that different doses (measured with an ionization instrument in r) are required for a given effect upon the skin, using rays of longer or shorter wave length For instance, with rays produced with 200 K V pulsating voltage, ordinarily 750 r are required for an erythema dose (7), while for non-filtered rays produced with from 70 to 80 K V pulsating voltage, only 340 r are sufficient to produce a similar effect upon the skin (8)

Then, in the second place, we have to keep in mind that with ionization measurements, we are really determining the effect of the rays upon a small volume, *i e*, that equal to the volume of the ionization chamber, and that these measurements give or imply no information regarding the total dose or radiation quantity delivered to the rest of the body tissues Let us consider an example If the skin is irradiated with long wave length rays, then the dose measured with an ionization chamber is approximately equal to that which is absorbed in the skin, therefore, the measured dose of 340 r is practically all absorbed in the skin, causing the erythema effect If, however, the surface of the body is irradiated with highly penetrating filtered rays, then the ionization chamber measurement of 750 r

again indicates approximately the effects of the radiation upon the skin, but in addition to that, there are large doses delivered to the deeper parts of the body Evidently different biological effects must be expected in the two cases, in the first, when the radiation effects are superficial and on the skin only, there can be expected no very great effects upon the blood system or upon the internal, more deeply located parts However, when, in addition to the effect so produced upon the surface layers, there is also extensive irradiation of the blood-containing organs and other radiation-sensitive body parts, such as takes place when short wave length filtered rays are used, then the picture as it applies to end-results must be a different one Confirmation of this view is found extensively in the literature, and the cases of early radiation injuries, in the sense in which they differ from the more recent kinds of internal roentgen injuries, are further direct proof

It follows therefrom that the  $\gamma$ -ray doses transmitted through protective screens, as measured with ionization chambers and expressed in r, are in themselves not a sufficient or a complete indication of the safety from, or magnitude of, danger with respect to the possibility of radiation injury to the blood system or to internally located radiation-sensitive body parts It appears, therefore, that the safety rules now accepted and followed may have to be changed so as to provide sufficient and adequate protection to prevent the developing of serious internal injuries, such as are now possible and probable due to over-radiation from insufficient protection

*Experimental Conditions*—As outlined in the foregoing paragraphs, we have at this moment reliable proof that doses measured by ionization of long wave length rays possess a greater degree of activity upon the skin or surface layers of the body than do equal doses of short wave length rays, such as are applied for deep therapy The ratio, as known to-day, in terms of ionization measure-

ment, is as 340 r, for the low voltage unfiltered rays, is to 750 r, for high voltage filtered rays. This fact alone, or rather the great difference between the two doses producing supposedly equal surface effects, is a strong indication that the various wave length bands ought to be considered separately in the study of protection rules. But then, a similar proposition arises again, when we consider more in detail the experimental conditions under which the safety tolerance dose was originally measured, as compared with the conditions under which the measurements for determining the appropriate lead thicknesses for adequate protection were made.

The safety tolerance dose was measured by the author in 1926 with an instrument of a comparatively large volume and with chamber walls which are highly transparent to long wave length  $\gamma$ -rays. It should also be understood that in all these measurements there were not only direct or short wave length rays present in the stray radiation, but also a considerable quantity of secondary radiation intensities (an average of approximately 50 per cent), coming either from the patient or from other irradiated objects. It is, therefore, quite definite that the original measurements include not only direct and short wave length rays from the tube, but also a considerable percentage of indirect secondary or longer wave length rays. The intensities originally measured, therefore, represent two components, each of which has a different activity upon the surface tissues, and of which one only, the short wave length component, is penetrating enough to be able to reach the internal body parts.

However, the absorption measurements of Kaye, Berthold, Glocker, van der Tuuk and others<sup>3</sup> were made in the customary manner, back of lead screens and with small volume ionization chambers. The intensities so measured are, therefore, only those of well-filtered, highly penetrating rays coming directly from the tube, and no secondary rays or rays of a different wave length are included. Rays of this

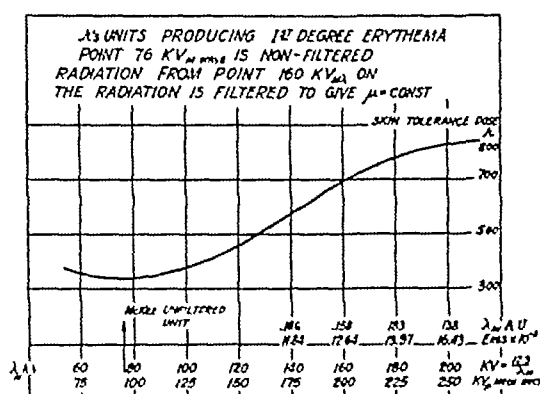


Fig 1 Number of r required at various voltages to produce a first degree erythema dose

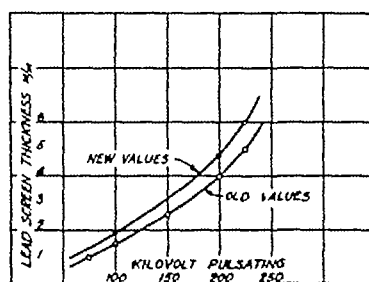


Fig 2 (Lower curve), Lead thicknesses specified in U S Bureau of Standards Handbook No 15, (upper curve) lead thicknesses required for adequate protection at various voltages

quality are known to be relatively less actinic upon the surface layers and to require around 750 r to produce a slight erythema. But, against that, they are highly penetrating and reach the internal body parts and, in particular, the blood and the blood-forming organs.

If now, we accept the safety tolerance dose proposed by the author (or any other definite tolerance dose), we should know the relative intensities of the various wave length components present in the stray radiation against which we are to provide protection. This, as we have seen, is necessary for two reasons. First, should it happen that the entire dose of stray radiation consists of long wave length rays, then only  $1/100$ th part of 340 r, or 3.4 r per month (or  $3 \mu\text{r/sec}$ ), is permissible, while for the short wave length stray rays,  $1/100$ th part of 750 r, or 7.5 r per month (or  $7 \mu\text{r/sec}$ ), makes a tolerance

dose per month (6) According to our present knowledge, this dose is absolutely safe for continuous toleration by normal healthy individuals, provided that certain specified hygienic and recreational rules are followed From the physical point of view, therefore, it would seem that these measurements and the results embodied in the safety protective rules are sound and that they can be unhesitatingly recommended But there are now further facts regarding the rays of higher penetrative power which have become known through therapeutic application of  $\gamma$ -rays, and these facts give rise to new aspects

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TABLE I

K V	Absorption coefficient $\mu$ in Pb	Normal lead protective screen (mm)	Calculated for one-half intensity transmission (mm)	Percentage of increase
100	1 mm = = 65 1 5 = = 52 2 0 = = 45	1 5	1 9	25
200	1 mm = = 48 2 = = 36 3 = = 30 4 = = 28 5 = = 25	4 0	4 75	19
220	1 mm = = 38 2 = = 29 3 = = 25 4 = = 21 5 = = 18 6 = = 16	5 0	6 0	20

TABLE II

Points on dia- grams	Stray radiation from an internally shielded x-ray tube			Stray radiation from a non- protected tube in a lead glass bowl Plane parallel to tube			Stray radiation from a non- protected tube in a lead glass bowl Plane perpendicular to tube		
	Full intensity $\mu\text{r}/\text{sec}$	Filtered through 0.25 Cu $\mu\text{r}/\text{sec}$	Ratio at full and transmit- ted stray radiation through 0.25 mm Cu	Full intensity $\mu\text{r}/\text{sec}$	Filtered through 0.25 Cu $\mu\text{r}/\text{sec}$	Ratio at full and transmit- ted stray radiation through 0.25 mm Cu	Full intensity $\mu\text{r}/\text{sec}$	Filtered through 0.25 Cu $\mu\text{r}/\text{sec}$	Ratio at full and transmit- ted stray radiation through 0.25 mm Cu
1	3 23	1 26	2 55	1 7	0 30	5 7	40 0	4 2	9 5
2	3 22	1 25	2 56	2 1	0 35	6 0	9 7	3 0	3 2
3	3 55	1 1	3 10	33 0	2 4	14 0	57 0	5 0	11 3
4	7 18	1 7	4 20	61 0	2 8	21 4	65 0	3 3	19 2
5	11 7	4 6	3 46	85 0	5 0	17 0	83 0	4 7	17 7
6	1 9	0 72	2 65	114 0	5 0	22 0	106 0	4 4	24 3

reading had been taken, the chamber was covered with 0.25 mm of copper as a filter for the stray radiation. On the average, when secondary radiation was present, the difference indicates an absorption of long wave length components, averaging slightly less than 50 per cent. This test, therefore, definitely proves that in many therapy clinics the stray radiation consists of a mixture of long and short wave length components.

(2) The intensity of well-filtered short wave length radiation transmitted through

various lead thicknesses was measured with the same instrument, and 0.25 mm of copper was placed into the beam in addition to the lead. There was only a very slight decrease of radiation intensity caused by the 0.25 mm of copper, *i.e.*, corresponding to the theoretically required amount. This shows that no secondary rays are present in the directly transmitted stray radiation.

(3) The intensity of secondary radiation from an irradiated block of pine wood of form and size similar to that of a

dose Secondly, if, for instance, the stray radiation should consist entirely of well-filtered, highly penetrating rays and operators are exposed to the full permissible tolerance dose of  $1/100$ th of an erythema

secondary rays, the biological effectiveness of the radiation is of the order of 750/340, or 2.2 times as large as the known tolerance dose In case the stray radiation consists entirely of direct, well-filtered rays

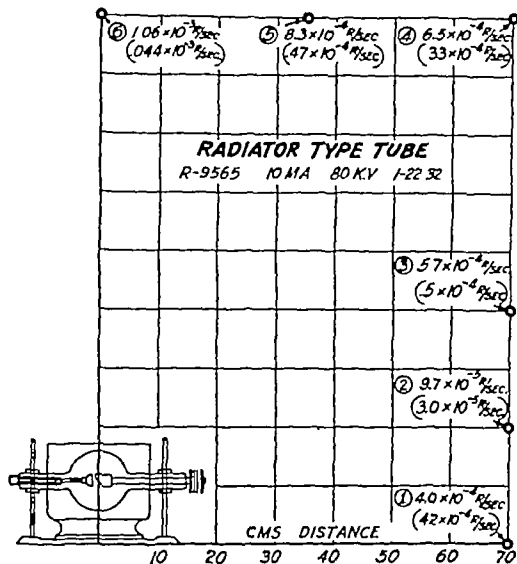


Fig 3 Straight radiation intensities measured near the Universal type hot cathode tube

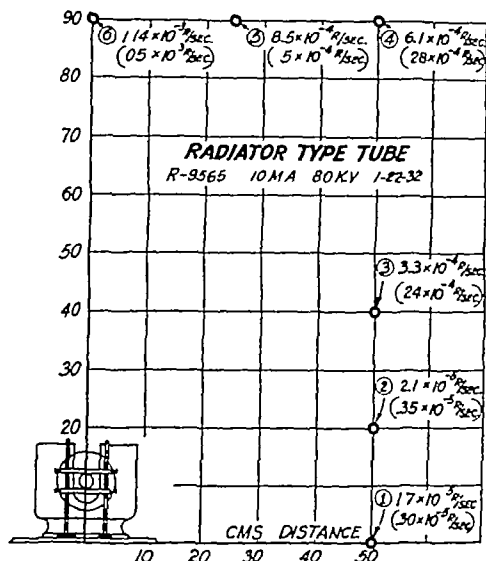


Fig 4 Stray radiation intensities of hot cathode type tube measured at 90° of Figure 3

dose, or to 75 r per month, then their internal organs would receive a considerably larger dose than that which corresponds to the proposed tolerance dose This is so because the proposed tolerance dose contained only a fraction of short wave length rays, whereas the administered dose would consist of a full dose of penetrating rays<sup>2</sup>

In both cases, therefore, unless we are quite certain that the stray radiation consists of the same mixture of ray components for which the tolerance dose was originally measured, it would seem certain that the doses actually reaching the operators are considerably larger doses than those upon which the present accepted safety rules are based In case the stray radiation consists entirely of

coming directly from the tube through the screen, then the dose received by the internal organs would be about twice what it would be according to the accepted safety tolerance dose

In all cases, therefore, we are forced to conclude that the now accepted lead thicknesses are inadequate unless the assumed tolerance dose value is changed So long, however, as there is no indication that this tolerance dose is underestimated, it is absolutely necessary, in order to be consistent, that these conditions be considered when recommendations for thicknesses of protective lead screens are made

*Experimental Work*—Some further deductions relative to the correctness of these conclusions can be made from the following experimental results

(1) The stray radiation was measured with a large volume ionization chamber in several therapy clinics<sup>3</sup> After the first

<sup>3</sup> For a description of the ionization chamber see RADIOLOGY, April 1926

<sup>2</sup> This dose has also been expressed for normal working conditions either as one full skin dose in 20,000 hours, or as a continuous irradiation dose calculated for working hours of an intensity of 7μr/sec (1μr = one micro-roentgen =  $10^{-6}$ r)

TABLE I

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reading had been taken, the chamber was covered with 0.25 mm of copper as a filter for the stray radiation. On the average, when secondary radiation was present, the difference indicates an absorption of long wave length components, averaging slightly less than 50 per cent. This test, therefore, definitely proves that in many therapy clinics the stray radiation consists of a mixture of long and short wave length components.

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(3) The intensity of secondary radiation from an irradiated block of pine wood of form and size similar to that of a



patient was then measured. When a 0.25 mm copper filter was placed into the path of the rays, before they reached the ionization chamber, their intensity was decreased to about 40 per cent of the original in-

that ionization measurements alone are not a conclusive indication of the adequacy of protection, and that in order to maintain that accepted standard of protection, the absorption values of protection screens

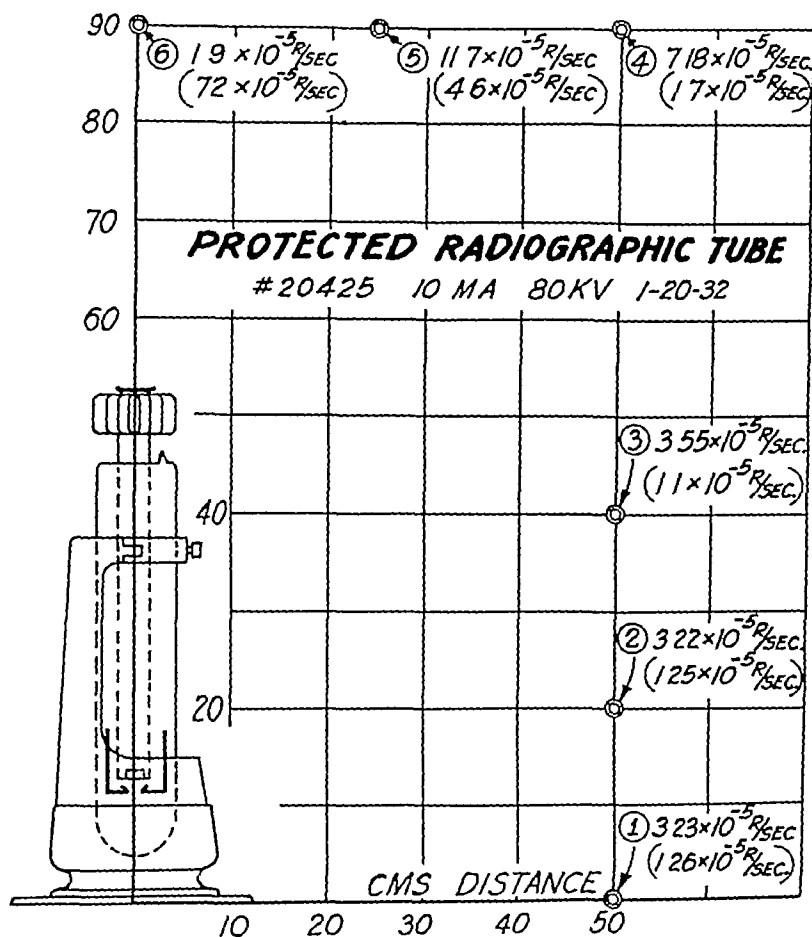


Fig 5 Stray radiation intensities measured around hot cathode heavy protected x-ray tube

tensity. A filter of 0.5 mm copper decreased this intensity still further—to a total value of about 18 per cent of the original intensity. These measurements show that the secondary radiation is a long wave length radiation, and generally quite completely absorbed in the outer layers of the body.

This review of given actual conditions, and the results of these simple tests, force upon us the rather definite conclusion

must be increased to transmit only about 50 per cent of the radiation intensity for which they are now accepted.

#### CONCLUSIONS

With the recognition of incorrectness of the previously used numerical data for calculating safety screens, naturally there arises the necessity of deriving, as far as possible from experimental results, their

correct values. In the present case, we have the correct physically measured recommendations for lead screens for various voltages of Glocker and his co-workers, also embodied in the U S Bureau of Standards Handbook No 15.

But, as the result of the preceding discussion, we have found that under ordinary conditions, the radiation doses transmitted through these screens may be on an average 2.1 times as large as the doses they are assumed to be, *i e*, in respect to their biological effectiveness as it compares with the transmission measurements made with ionization chambers behind lead screens. In order, therefore, to attain the desired protective screening in all cases, it is necessary to reduce the stray radiation intensity to about one-half in order to be assured of the absence of radiation injury.

From the data of Kaye and Berthold we have absorption coefficients in lead at various thicknesses and of radiations of various voltages (Table I). From these we can calculate the increase in lead thickness required to obtain the desired reduction in the intensity of the stray radiation.

The radiation intensity transmitted through a filter is equal to

$$I_0 e^{-\mu x}$$

where  $I_0$  is the intensity of the incident radiation,  $\mu$  the absorption coefficient,  $x$  the thickness of the absorber,  $e$  equals 2.70.

Utilizing, therefore, the data given in the table, and with the aid of the following equation, we can find the lead thickness required to reduce the stray radiation intensity to  $1/2$  of that which is now recommended and considered as standard. Utilizing, for instance, the data from the table for 200 kilovolts

$$\frac{\text{intensity through } 40 + x \text{ mm Pb}}{\text{intensity through } 40 \text{ mm Pb}} = \frac{e^{-\mu x}}{e^{-11.2}} = e^{-\mu x + 11.2} = e^{-7}$$

From this we obtain  $\mu x = 11.9$ , since from Kaye and Berthold's tables, we have  $\mu = 25$

$$x = \frac{\mu x}{\mu} = \frac{11.9}{25} = 4.75 \text{ mm of lead}$$

Column 4 of Table I gives the increases in lead thickness found necessary, which leads to the result that in order to be certain of the expected protection safety against stray radiation, there is required an increase of lead thickness of approximately 20 per cent to 25 per cent.<sup>4</sup>

Figure 2 shows curves of the old and the new values of lead thicknesses for protective screens. These agree quite closely with the author's earlier recommendations.

*Discussion*—The final and probably the most important discussion should be one dealing with practically valuable results. Hence, the measurement and discussion of the stray radiation intensities around x-ray tubes employed in actual diagnostic work might be particularly suited to demonstrate and establish the actual importance and practical value of the corrected protection specifications.

With this end in view, the stray radiation intensities near several x-ray tubes was measured for the purpose of concluding upon the adequacy or sufficiency of the provided protection features. Evidently, from what we have seen in the foregoing, we can make a comparison of the stray radiation intensity from an internally protected x-ray tube against that from a non-protected tube housed in a conventional protective lead glass bowl, or we can determine the distance required from the tube at which the accepted safety tolerance dose in its corrected form is not exceeded.

Figure 5 is a cross-sectional outline of an internally shielded or protected type

<sup>4</sup> From the lead absorption curves of Herrmann and Jaeger (Fortsehr a d Geb d Röntgenstr, 1930, XLII, 115) it is found that in order to obtain a similar decrease of the stray radiation intensity with 220 kilovolts, a lead thickness increase of about 30 per cent must be made.

of x-ray tube Figure 3 shows a similar outline of a non-protected tube which is supported in a conventional lead glass bowl, and Figure 4 is a cross-section of the same tube but in a plane at  $90^\circ$  from that of Figure 3. On the diagrams are entered the radiation intensities measured at given distances when the tubes are operated at 80 peak kilovolts and 10 milliamperes of pulsating tube current.

These intensity measurements were all made with the same dosage instrument employed for the determination of the original safety tolerance dose and all the other data reported in this paper. These data, therefore, are in particular truly relative to the stray doses reported, and hence fully in terms of the original tolerance dose. The same measurements were then repeated with the ionization chamber covered with 0.25 mm of copper as a filter for the stray radiation. The readings obtained are given in Table II and they are also entered on the diagrams, the figures being surrounded by brackets. These results, shown in Columns 4, 7, and 10 of Table II, definitely indicate that the stray radiations, when different methods of protection are applied, are not of the same composition and also that their composition differs in the various directions from the x-ray tube. Therefore, the intensities as measured by ionization, without regard to the composition of the beam, cannot be taken as reliable indication of the tolerance dose. Therefore, in order to be safe against all possible kinds of stray radiations, we categorically have to increase the protective values of all protective devices by about 50 per cent.

In order to arrive at a decision regarding the sufficiency of the protection, it is required to know the total radiation produced in the tube during the period of one month. In several busy x-ray departments of large hospitals in New York City, the total number of exposures, their duration, and the tube current used during each, were tabulated. The largest value recorded was 18,000 milliamperes-seconds in one day, which makes  $3.54 \times 10^6$  ma -

sec per month. With an average tube current of 10 ma, the time is  $3.54 \times 10^4$  seconds. The greatest stray radiation intensity back of the tube (operating with 10 ma), shown in Figure 5, is  $11.7 \times 10^{-5}$  r/sec. This makes in one month a total dose of stray rays of  $11.7 \times 3.54 \times 10^{-1} = 4.14$  r/month. This is at a distance of 40 cm from the radiator of the x-ray tube.

From Figure 1 we find that a tolerance dose of  $1/100$ th of an erythema dose would be 4 r/month. Reducing this intensity to 50 per cent, as is required, makes the safe tolerance dose equal to 2 r/month.

With the inverse square relation we find that at the distance of

$$X = \sqrt{\frac{40^2 \times 4.14}{2}} = 57.3 \text{ cm}$$

from the radiation of the tube the safety tolerance dose is not exceeded.

Calculating in a similar way the stray intensity on the side of the tube, we find that  $3.55 \times 10^{-5}$  r/sec in  $3.54 \times 10^4$  sec gives a total dose of 1.26 r, which, at a distance of 50 cm from the center of the x-ray tube, is still lower than the permissible tolerance dose of 2 r per month.

The ratios of the full radiation intensities, divided by the filtered values measured (through 0.25 mm Cu), given in Column 4 of Table II, show fair constancy, which indicates that from the internally shielded tube, great variations in the composition of the stray radiation are not present. Calculations similarly made for the non-shielded tube in a conventional lead glass bowl reveal that alongside of the bowl but still below a plane through its upper brim, the stray radiation dose is not in excess of 2 r/month. However, above the brim of the bowl or endwise in a plane through the slots, the stray radiation intensities are very highly non-homogeneous, which is indicated by the great variation of the non-filtered and the filtered intensity ratios given in Columns 7 and 10 of Table II, but then the intensities of stray rays are considerably larger than the safety tolerance

dose—in some directions about a hundred times the permitted intensity for the safety tolerance dose

#### SUMMARY

1 X-ray over-radiation injuries are of two kinds—external or skin lesions and internal or blood and organic changes

2 Physical measurements of Behnken, Glocker and their associates, while physically correct, cannot be employed directly for the final determination of the thickness of protective screens

3 The composition of the stray radiation has an important bearing on the biological effects

- (a) for the reason that different wave lengths require different numbers of  $r$  for an erythema, and
- (b) because short wave length filtered rays have smaller surface, but larger effects on internal organs, blood, etc

4 The safety tolerance dose was originally determined for a stray radiation of mixed wave lengths, hence, transmission values measured through lead screens have different biological effects

5 For unknown mixtures of stray rays, the stray doses should be about 50 per cent, so that in all cases the assumed or accepted safety tolerance dose is not exceeded

6 The thicknesses of lead screens determined from physical measurements should be increased in order to provide in all cases that safety which they are assumed to give

7 It is experimentally shown that stray radiations are heterogeneous and, hence, that the recommended thickness increases for protection screens are justified

8 The actual thickness increases necessary are calculated and represented in a curve for various voltages

9 It is shown that the stray radiation from an internally shielded x-ray tube is relatively homogeneous, *ie*, full stray radiation + filtered stray radiation = small ratio

10 It is also shown that stray radiations reflected from glass shields, wood, etc, are highly heterogeneous, *ie*, full stray radiation + filtered stray radiation = large ratio

11 It is pointed out that internally shielded x-ray tubes offer very much safer protection than non-protected tubes housed in conventional lead glass shields

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# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## ROENTGEN DIAGNOSIS IN PRIVATE PRACTICE<sup>1</sup>

The tremendous increase in the use of the roentgen ray in diagnosis is a striking development of modern medical practice. In a recent survey we found that some 55 per cent of all the patients admitted to the University Hospital came to the x-ray department for some diagnostic procedure. At the Mayo Clinic it has been estimated that about 80 per cent of the patients have some form of x-ray study during the course of their examination. In no disease is the need for adequate roentgen examination more vital than in carcinoma of the stomach and in pulmonary tuberculosis. In these two serious conditions early diagnosis is of the utmost importance and an early diagnosis is possible in a very high percentage of the cases by the roentgen method.

It is, therefore, significant and tremendously disappointing to consider the following data. In a survey of 100 cases of carcinoma of the stomach, only 26 had had x-ray examination before entrance into the hospital. Of these 26, only four had been diagnosed correctly, while in the other 22 the diagnosis was either doubtful or negative. In a larger series of cases suspected of having pulmonary tuberculosis the results of x-ray examination were almost as bad, except that here the errors were mostly on the positive side. When it is considered that in competent hands the x-ray diagnosis of carcinoma of the stomach can be made correctly in at least 90 per cent of the cases, and in pulmonary tuberculosis the accuracy is even greater, it can be realized that there is need for an increase in the quality as well as the quantity of our x-ray examinations.

Roentgenology is a specialty in medicine. It has been so recognized by the American Medical Association for a number of years. The recent organization of an American Board of Radiology for the purpose of certification by examination of qualified practitioners in this

field is the final step in the development of this specialty. The purpose of the Board is to raise the standards of training and qualifications of the physicians who are practicing roentgenology or radiology as a specialty, and thus to raise the quality of the roentgen examinations which are done. Unfortunately, only a very small part of this purpose can be accomplished in this way. The fact is that the vast majority of the x-ray examinations of patients are made by general practitioners, internists, surgeons, or specialists in other fields, rather than by roentgenologists.

In this matter of who shall make the x-ray examination of Dr. John Doe's patient, there is the most striking discrepancy between group or public practice and individual or private practice. In this country to-day, if a patient comes to a municipal or a federal hospital, to a public clinic, or, in the vast majority of cases, to a private clinic or private hospital, he will have his roentgen examination attended to by a well trained specialist in this field, by a man who is devoting all his time to this complex and difficult subject. If, however, this patient presents himself to Dr. John Doe's office, he may have this examination done very differently. It may be done by Dr. Doe himself, although the only qualification the Doctor may possess is that some supersalesman sold him an x-ray machine. It will frequently be done by his office partner who may have more experience, having possessed his x-ray machine for a longer period of time and having examined more patients during this period of time. Occasionally Dr. Doe is a specialist himself in the field in which the patient's complaints lie, or he may send the patient to a gastroenterologist, a chest specialist, or some other specialist. In that event the examination may be done by the specialist, who will usually be better qualified than the general practitioner. Finally, and in the minority of cases, the patient will be sent to a roentgenologist and get the same expert examination that he would have obtained if he had been sent to a hospital, whether municipal or private, or had gone to a free clinic.

The cases referred to at the beginning of this

<sup>1</sup> Reprinted by permission from the 'Bulletin of the Hennepin County Medical Society' April 10 1934 V, 44

discussion came almost exclusively from small rural communities. The x-ray examinations were done in the vast majority of instances by general practitioners to whom no expert roentgenological service was available. No criticism of these physicians is justifiable in spite of the poor results of their roentgen diagnostic work. They are doing the best that can be expected of them under difficult conditions. But what excuse is there for this type of work in a large city where adequate x-ray consultation is readily available? Numerous reasons have been given for Dr. Doe's purchase of an x-ray machine and his efforts to do his own x-ray work. The most frequent of these reasons is the matter of expense to the patient. Dr. Doe says that this examination costs the patient much less than would that of the roentgenologist and his patients are not wealthy and cannot afford any luxuries. As a matter of fact, this is not true. There is every reason to believe that a specialist in this field doing a considerable amount of work in it all the time can do it more cheaply than the practitioner who does only an occasional case. The difference in cost is only apparent. It is due to the fact that Dr. Doe is willing to make an examination of poor quality, to do a fluoroscopy where films are indicated, to take one film where many are necessary, etc., and also to the fact that Dr. Doe is not charging the patient for his services in this examination. This is perhaps justifiable in view of the fact that his services in this regard are frequently worth nothing. The patient may pay less in money, but his proportionate return is usually even less.

There would seem, in many instances, to be some plausible excuse for a man practising a rather restricted specialty, such as orthopedics or urology, to do his own roentgen examinations. There are numerous factors, even under these conditions, which militate against the patient obtaining the best results from such an examination, but what reasonable excuse there is for an internist, a general surgeon, or a general practitioner in a large city to practise roentgenology as a sort of side line is difficult to see. It leads inevitably to poor roentgenologic work, it is deleterious to the best interests of the patient, and certainly leads to no good for the medical profession. As our sociologists and publicists who are agitating for a change in the form of medical practice contemplate the difference between the methods

of x-ray examination in group practice and in private practice and also observe the corresponding difference in the quality of the examination, they may certainly be pardoned for some skepticism as to the benefits of the individual practice of medicine, at least in this one regard. A proper regard for the best interests of the public and of the medical profession itself should lead to a different method for conducting x-ray examinations in private practice.

LEO G. RIGLER, M.D.

## COMMUNICATIONS

### THE FIRST DEEP ROENTGEN THERAPY PRIORITY FOR THE TREATMENT OF LEUKEMIA<sup>1</sup>

A REPLY TO DR. W. A. PUSEY

By U. V. PORTMANN, M.D., *Cleveland Clinic, Cleveland, Ohio*

I have studied with interest the comments of Dr. W. A. Pusey entitled "The First Deep

<sup>1</sup> The following correspondence took place between Dr. Portmann and Dr. Pusey following the publication of the latter's paper. It is self-explanatory.

*Letter Submitting Manuscript to Dr. Pusey*

March 17, 1934

DR. WILLIAM A. PUSEY,  
7 West Madison Street,  
Chicago, Illinois

DEAR DR. PUSEY: I was very much interested in your comments on the first deep roentgen therapy which appeared in the January number of *RADIOLOGY*. I have reviewed the whole subject again, and have prepared a short answer to your criticism which I am going to send to the Editor of *RADIOLOGY*. I am sending a copy to you first, however, and should appreciate it very much if you could go over it and send me any criticisms, comments, or suggestions. I am holding the copy for *RADIOLOGY* until I hear from you.

With kind regards and all good wishes, I am

Yours very truly,

U. V. PORTMANN, M.D.

*Dr. Pusey's Reply*

April 5, 1934

DR. U. V. PORTMANN,  
9204 Euclid Avenue,  
Cleveland, Ohio

DEAR DR. PORTMANN: Thank you for sending me your comments in reply to mine on the subject of the first deep roentgen therapy. I should have replied to you sooner but I have been out of the city.

*Radium Therapy*," in the January, 1934, issue of RADIOLOGY, concerning statements made in the chapter on "*Roentgen Therapy*," which I wrote for "*The Science of Radiology*." Although Dr Pusey's communication appeared as a surprise to me, his comments are appreciated because I recognize his preëminent distinction and the inestimable value of his primigenous contributions to roentgen therapy.

It must be obvious that there were difficulties involved in writing such a brief chapter on the comprehensive subject of roentgen therapy. There were limitations of time and

space which prevented detailed explanations and prohibited a complete bibliography of the numerous publications reviewed. It was a precarious task to select and cite the publications which dealt with the question of priority and, at the same time, to avoid expressing the opinion of one individual. Therefore it is stated in the first paragraph of the chapter, "I do not presume to be an authority on the debatable question of priority." Every effort was made to give the evidences as they appear in a general survey of the literature.

According to the general consensus of opinion, priority for an accomplishment is estab-

I confess I do not see the validity of your position that Senn is entitled to the credit for priority because he reported the first *successful* treatment of leukemia with x rays. But I do not believe that even that contention can be maintained for in my book on Roentgen Rays, published on June 1, 1903, I reported a case of leukemia which had been treated successfully in the same sense that Senn had successfully treated his case, reported in August, 1903. This was a case of leukemia whose treatment began March, 1901, and continued for more than one year, in which there was disappearance of many glands, decrease in size of the spleen, reduction of white corpuscles from 74,000 to 12,000, and great improvement in the patient's general condition. This case is described in some detail on page 552 of the first edition of "*The Roentgen Rays in Therapeutics and Diagnosis*," Pusey-Caldwell. The diagnosis was made by Dr Jacob Frank, Dr Frank Billings, and others. At the same time I reported the death of the patient later, but that undoubtedly happened with Senn's patient, as it did with all other leukemia cases. For more than a year before as I recited in my previous comments, these cases of lymphoblastoma were being treated by many men and the method of treatment was well recognized.

I cannot see the force of the comment, in this connection, that leukemia is a very different thing from pseudoleukemia. The clinical and the essential similarity between the two diseases is so close that it was inevitable that as soon as pseudoleukemic masses had been cleaned up with x rays, the treatment would be tried in leukemia. I and many others did it.

As to the point that Senn reported a successful result and the rest of us did not, that would simply seem to be penalizing conservatism. All of the rest of us reported the disappearance of lymphoblastomatous tissue under x-rays. We reported the facts, which were symptomatic improvement and symptomatic cures but we, it would seem properly, restrained ourselves from making any further claims. In Senn's case, reported as successfully treated the only difference was in the claim.

As far as our being at least agreed that I had nothing to do with Senn's case, the same also may be said almost literally of Senn. If any persons should be given credit in Senn's case, they are the member or members of the house staff of St Joseph's Hospital who suggested the use of x-rays to Senn in his first case of pseudoleukemia, and Dr W F Buttermann of St

Joseph's Hospital, and Dr Joseph F Smith, of the Presbyterian Hospital, the roentgenologists who carried out the treatment of his cases of pseudoleukemia first, and then of his leukemia case. They are the "mute, inglorious Miltons" in this situation. In Senn's reports he makes no reference to the work which had already been done with x-rays in these cases. The most satisfactory explanation of this omission is that the method had become so well established that he thought reference to this fact was unnecessary. This is supported by his statement that I prescribed as usual, arsenic and iron, and, in view of the heretofore hopelessness in such cases, advised, in addition, the use of the roentgen ray." This matter-of-fact statement of the advice of x rays in the case would indicate that he assumed that the use of x-rays in such cases had become a method of treatment sufficiently well recognized to require no comment. He would otherwise hardly have picked so unusual and original a treatment of leukemia out of the air, as it were, without explaining the reasons for so doing.

I would be glad if these comments could be published with your letter.

Yours sincerely,

W A PUSEY M D

#### *Letter Replying to Dr Pusey*

April 18 1934

Dr WILLIAM ALLEN PUSEY  
7 West Madison Street,  
Chicago Illinois

DEAR DR PUSEY: Thank you very much for your letter of April fifth in regard to our discussion. I am sure that if you go over my article again you will find that I make no statement, but only give historical facts as published in the literature.

Of course, there is evidence that leukemia was treated by roentgen rays prior to the case of Senn. However, I think that it should be left up to the readers to try to decide if they wish to take any definite stand.

I shall send your letter to Dr Menville the Editor of RADIOLOGY, and he can use it as he sees fit. Thanking you again for writing and with regards, I am

Yours very sincerely,

U V PORTMANN M D

lished on the basis of the earliest report of success or of positive results. To show that priority is actually properly accredited in the chapter on the points which Dr. Pusey questions, let me quote from it: "Those who first reported their success and are generally given credit by authorities for priority in treating various conditions are as follows: leukemia and lymphadenomas, Pusey and Senn, 1903." In addition, the early, admirable publications of Dr. Pusey, and those of others, on Hodgkin's disease (lymphadenoma) as well as other conditions, are cited on pages 222 to 224.

Dr. Pusey brings out one point in his communication, the accuracy of which cannot be disputed, when he writes that he "had nothing to do with the x-ray treatment of Senn's cases." For having repeated this mistake, which is made in a number of publications, I wish to express my regret. The error might have been avoided had there been time enough to corroborate each detail by personal communication with the living authors whose work was discussed.

Dr. Pusey states in his communication in *RADIOLOGY*: "Previous to the time of Senn's report the following reports of cases of leukemia and pseudoleukemia treated with roentgen rays, in some cases with symptomatic cure, had been made." That Dr. Pusey and others wrote on pseudoleukemia prior to Dr. Senn's work on leukemia is well established in the chapter, as shown by the large bibliography listed which includes most of the references which Dr. Pusey cites in his comments.

The point about pseudoleukemia (Hodgkin's disease, lymphadenoma) having been agreed upon, let us now study the articles which Dr. Pusey gives in his comments in order to determine whether or not they confirm his contention that the authors report favorably upon the roentgen treatment of leukemia prior to the publication by Dr. Nicholas Senn of his paper, "A Case of Splenomedullary Leukemia Successfully Treated by the Use of the Roentgen Ray" (*Med Rec*, Aug 22, 1903, LXIV, 281). As far as I have been able to ascertain, and according to others who undoubtedly have searched the literature with equal thoroughness, this was the earliest specific report concerning leukemia that included clinical details satisfactorily proving successful roentgen treatment.

The first article to which Dr. Pusey refers as evidence that there were "reports of cases

of leukemia and pseudoleukemia, treated with roentgen rays," prior to Dr. Senn's article is, his own publication "Cases of Sarcoma and Hodgkin's Disease Treated by Exposures to X-rays—A Preliminary Report" (*Jour Am Med Assn*, Jan 18, 1902, XXXVIII, 166-169). This reports the treatment of three cases of sarcoma and two cases of Hodgkin's disease, but there is no mention of leukemia.

Dr. Pusey's second reference is to his article, "Report of Cases Treated with Roentgen Rays" (*Jour Am Med Assn*, April 12, 1902, XXXVIII, 911-919), a discussion of 36 patients with several different diseases, including the cases of pseudoleukemia and sarcoma previously reported. In a short paragraph on leukemia an additional case is mentioned and the author states: "I have exposed one case of splenic leukemia to x-rays. She was given x-ray exposures over the spleen for a month with no effect whatever." In my judgment the case shows nothing. There is no statement about any favorable results.

The next publication that should be reviewed although not mentioned in Dr. Pusey's recent communication, is his own book, written in collaboration with Eugene Caldwell, entitled "The Roentgen Rays in Therapeutics and Diagnosis," first published in June, 1903, by W. B. Saunders Co., Philadelphia. The authors discuss "two cases of true leukemia" on page 552. Dates are not given in the history of the first case, but it is apparently the patient previously reported by Dr. Pusey as of April 12, 1902, and the statement made in that article is repeated in the book: "She was given x-ray exposures for a month with no effect whatever." The second patient seems to have had lymphatic leukemia. They say, "the disappearance of the tumors was in close sequence with x-ray exposures," and in the discussion of the case it is said that the patient did not continue treatment long enough. There is no statement about a favorable result, as a matter of fact, the blood counts tabulated show that the number of white cells increased from March to September, during the course of treatment.

These publications by Dr. Pusey indicate that, although he treated leukemia by roentgen rays before 1903, he did not believe that there was any benefit, but, on the contrary, observed "no effect whatever," and so reported.

The third article referred to by Dr. Pusey,



"The Use of X-rays in Cancer, Lupus, and Hodgkin's Disease," by F W Hett (*Dominion Med Monthly*, August, 1902, XIX, 76-80), is a report of the roentgen treatment of seven cases, including one of Hodgkin's disease, but there is no mention of leukemia

Dr Pusey's fourth reference is the article by Dunn, "The Therapeutic Uses of the X-ray, with Report of Cases" (*Am Pract and News*, Oct 1, 1902, XXXIV, 263-275), in which the author tells of his experience in the treatment of 23 cases, including one of "pseudo-leukemia (Hodgkin's disease)," but does not mention leukemia

In the article "Cases Illustrating the Therapeutic Uses of the Roentgen Rays," by S B Childs (*Medical News*, Jan 24, 1903, LXXXII, 145-149), to which Dr Pusey also refers, the author states "It includes six cases of epithelioma, one of carcinoma, three of lupus erythematosus, one of chronic eczema, one of tubercular glands, one of tuberculosis pulmonalis, and one of Hodgkin's disease" There is no report on leukemia

Dr Pusey's last reference is to "Williams' book on 'Roentgen Rays,' published about March, 1903" There were three editions of "The Roentgen Rays in Medicine and Surgery," by Dr Francis H Williams (*The Macmillan Co*, New York) The first edition appeared in 1901 and was the first American text-book on the subject The second edition was prefaced and appeared in 1902, and the third in 1903 and is more comprehensive than the others Dr Pusey in his communication refers to the last (1903) edition. In none of them is leukemia mentioned in the bibliography, the index, or the text The only conceivable reference to leukemia is in the second (1902) edition, in which there is an addenda slip inserted (page 225) which lists a few diseases treated by Williams, among them "some forms of enlarged spleen" However, in the third edition (1903) even this indefinite reference is entirely lacking In both the second and third editions of Williams' book, Dr Pusey's cases of sarcoma and Hodgkin's disease are discussed and the bibliographic references given are to the two articles herein mentioned

It is undoubtedly true that leukemia had been treated by roentgen rays before Dr Senn's trial of the method, but no one seems to have reported favorable results and Dr Pusey's references do not prove that the treat-

ment of leukemia was successful "a year before Senn made his report," nor that there were other reports to this effect Let me repeat that this does not apply to pseudoleukemia (or Hodgkin's disease, lymphadenoma), which is entirely different in its clinical and anatomic pathologic manifestations

Let me now explain the reasons for the following statement, to which Dr Pusey seems to object, *i e*, "Dr Nicholas Senn, of Chicago, really founded deep roentgen therapy when he reported favorable results from roentgen irradiation of the spleen in patients suffering from leukemia This latter report proved that roentgen rays had deep effects," etc This was not an expression of my own or any one individual's personal opinion

I grant that the question as to when, how, or by whom "deep" roentgen therapy was founded is debatable One might contend, with some justification, that the very first attempts to use the rays therapeutically in 1896 were the beginning of deep therapy, but this is not generally conceded For example there were trials at treating pulmonary tuberculosis and Despeignes treated carcinoma of the stomach at that time, and in the next few years of earnest investigation the rays were applied empirically for a great many different diseases, including deeply located lesions But it is obvious, as one reviews the early literature, that up to about 1903, success with roentgen therapy was reported only in skin diseases, superficial ulcerations, or neoplasms Apparently little credence was given to a few sporadic claims of benefits to deeply situated lesions, because these observations were based mostly upon unreliable subjective statements and were not accepted as conclusive evidence of the beneficial effects of radiation

Undoubtedly deep roentgen therapy was gradually evolved, but was given a great impetus by certain clinical and laboratory findings among the first of which seems to have been the report of the reliable clinical observations of Dr Senn This detailed discussion by such a celebrated physician was interpreted by many individuals as an indication that roentgen rays had sufficient penetration to be therapeutically effective to internal organs, because he said that the size of the spleen was reduced and the white blood count was diminished in a patient with leukemia Experimental laboratory evidences were also presented in 1903 by Albers-Schönberg, who

produced aspermia in rats, and by Heineke, who discovered "the selective action of the rays upon lymphatic tissues and suggested the possibility of therapeutic application in certain diseases of the lymphatic system, including leukemia, which, unknown to him, had just been reported by Senn in the meantime"

Perthes also made a remarkable contribution when he reported, in 1904, on "the rate of absorption of roentgen rays in tissue" and found that "when the rays are filtered through aluminum the skin is protected and the intensity into the deeper layers is increased" It was Perthes' experiments that suggested the physical background of *homogeneous cross-fire* therapy, promptly advocated by Dessauer

It cannot be denied that all of these investigations were significant in founding deep roentgen therapy and the first of them was the clinical observation by Senn Perhaps Senn's article was not of consequence in the minds of some individuals, but others considered the report to be of signal import, especially in relationship to these other contemporary discoveries

To illustrate the influence and significance which Dr Senn's article had, especially abroad, permit me to translate and quote from two of many authoritative publications by contemporaries Oudin and Zimmern, in France, said "The first to utilize the  $\gamma$ -rays in the diseases of the leukemia group were Pusey and Senn The publication of Pusey (1902) passed unnoticed He reported a case of pseudoleukemia relieved by the rays and failure in a case of myelogenous leukemia with splenomegaly In the following year, Senn, of Chicago, published two favorable observations which were received with astonishment but did not convince, because it was impossible to believe, at that time, that an external treatment could have any effect upon blood changes, etc" (Radiotherapie, Roentgenotherapie, Radiumtherapie, Phototherapie P Oudin and A Zimmern, J B Baillière et Fils, Paris, 1913, pp 285, 286)

Prof G Holzknecht, another contemporary from Austria, wrote "In 1902 (*sic*) the medical world was startled by the really astonishing communication of the American physician, Nicholas Senn, of Chicago, who reported that it had been possible not only to change the

blood picture and to reduce the size of the spleen and enlarged glands in a case of leukemia by  $\gamma$ -radiation, but also to improve the serious condition of the patient At first this news was almost incredible, because up to this time it was unknown that the  $\gamma$ -rays had an effect upon internal organs Senn's communication gained credence when he also told about two cases of pseudoleukemia which had been treated with equal success, and when Albers-Schonberg (1903) reported the curious fact that aspermia had been produced in experimental animals by  $\gamma$ -rays Senn, therefore, seems to have been the founder of deep roentgen-ray therapy" A biography of Nicholas Senn is given and the discourse continues "In his own country there is disagreement But there is no question about the historical significance which these two publications had upon the whole medical world However, this is not the opinion of American physicians—where Senn is not considered to be the founder of deep therapy and is not given credit because such trials had been made prior to his but had not been published" (Lehrbuch der Strahlentherapie, Urban & Schwarzenberg, Berlin, 1925, Chapter I, 13-15)

Finally it has been shown from Dr Pusey's own publications that he and others had treated and reported success in the treatment of pseudoleukemia and that leukemia had been treated prior to Senn's trial, but that no one before him had reported favorable results Hence Pusey's report that there were "no effects whatever" did not have the same influence or historic significance as Senn's report of success On this basis it would seem justifiable to me, and others who have previously written upon the subject, to state that Senn's report on the successful treatment of leukemia was one of the first suggestions that the roentgen rays had a deep effect hitherto undemonstrated We may maintain with considerable satisfaction that an American is credited with being the founder of deep roentgen therapy

I have tried to present as concisely as possible and without prejudice, the evidences from the literature as they apply to Dr Pusey's objections and wish to thank the Editor for the privilege of publishing this detailed explanation

## FOURTH INTERNATIONAL CONGRESS OF RADIOLOGY

ZURICH AND ST MORITZ, SWITZERLAND

The Fourth International Congress of Radiology will be held at Zurich and St Moritz, Switzerland, from July 24 to 31, under the patronage of the President of the Swiss Confederation, Dr Marcel Pilet-Golaz. All the leading nations of the world, including the United States, will send delegations. The general program foresees meetings in the University and the Federal Institute of Technology at Zurich from July 24 to 28. There will be a delegates' luncheon on the opening day, with the Swiss Roentgen Society acting as host, also a reception and ball. A Festival of Swiss National Costumes is to be held in honor of the visitors on July 27. The trip to St Moritz, which is bound to provide much scenic entertainment, is scheduled for July 28, on which day a reception will be tendered to the delegates by this famous Engadine resort. A final banquet will be held on the closing day.

Mme M. Curie figures among the noted guests of honor of this Congress, and a number of American physicians will speak at different meetings.

## THE NEXT ANNUAL MEETING

Among the plans now being formulated for the Annual Meeting of the Radiological Society of North America is an innovation having to do with the Scientific Exhibit. Instead of compelling the exhibitor to spend long hours at his exhibit, repeating over and over again his explanatory remarks, a new plan is under consideration. It is, in brief, to allot each scientific exhibitor a fifteen-minute period when he may make a full exposition regarding his material. Announcements will be posted upon a bulletin board giving full information relative to the time at which scientific exhibitors will be present at their various booths for the purpose of answering questions.

There will be one session only in progress at any one time, so that those in attendance may hear all the papers read, if they so desire. Each one can "listen in" on all the papers and discussions, or select those in which he is particularly interested. It is thought that this arrangement will result in uninterrupted sessions, since members of the audience will

not be passing in and out to select papers from simultaneous sessions.

The Clinics that are in process of arrangement will be one of the outstanding features of our Annual Meeting this year. Such practical demonstrations will be inaugurated as to resemble closely a post-graduate course of instruction.

There will be a banquet, as in former years, for which the Local Committee is already arranging a fine program. There will also be the customary Counselors' Dinner and a Stag Night. The 1933 meeting having been a joint one with other societies, the customary procedure had to be varied, with the result that there were lacking many of the social features which have made the Annual Meetings of the Radiological Society of North America events to be anticipated with pleasure and viewed in happy retrospect. The officers and the Memphis hosts anticipate that none of these features shall be lacking from the 1934 meeting, and hope that the members will attend in unprecedented numbers.

As the plans mature, announcements will be made in succeeding issues of RADIOLOGY.

## ANNUAL MEETING OF THE MEDICAL SOCIETY OF THE STATE OF NEW YORK

UTICA, N. Y., MAY 14 15 16 1934

At this, the 128th Annual Meeting, the Section on Radiology elected the following officers for the coming year:

Donald S. Childs, M.D., of Syracuse, *Chairman*, Leo P. Larkin, M.D., of Ithaca, *Vice-chairman*, James M. Flynn, M.D., of Rochester, *Secretary*.

The program of the Section on Radiology follows:

Cancer of the Tonsil, James J. Duffy, M.D., New York.

Palliative Irradiation of Inoperable Gastric Cancer, George T. Pack, M.D., New York.

Cancer Research, Francis Carter Wood, M.D., New York.

Post-operative Roentgentherapy for Carcinoma of the Breast, Maurice Lenz, M.D., New York, and Haig H. Kasabach, M.D., New York.

General discussion opened by Douglas Quick,

M D, New York and Virginia K Frantz, M D, New York

Encephalography, Cornelius G Dyke, M D, New York

Discussion opened by Charles W Schwartz, M D, New York

Bronchography, Leopold Jaches, M D, New York, and I Scotty Schapiro, M D, New York

Discussion opened by James M Flynn, M D, Rochester

Small Intestine Major and Minor Motor Phenomena and Their Differentiation from Pathologic Lesions, Lewis Gregory Cole, M D, New York

Discussion opened by Donald S Childs, M D, Syracuse

Low and High Power Roentgenographic Studies of the Sigmoid, William H Stewart, M D, New York, and Henry E Illick, M D, New York

Discussion opened by Ulysses S Kann, M D, Binghamton

Excretion Urography and Its Value to the Radiologist, Leo P Larkin, M D, Ithaca

## CANADIAN MEDICAL ASSOCIATION

The Canadian Medical Association held its meeting at Calgary, Alberta, June 20-22, 1934. The Section on Radiology was under the Chairmanship of W Herbert McGuffin, M D, President of the Radiological Society, of North America. The program of the Section was as follows

Wednesday, June 20

SECTION OF RADIOLOGY *Chairman* W Herbert McGuffin, M D

Each paper, 20 minutes, discussion, 10 minutes

DR DIGBY WHEELER, Winnipeg Paranasal Sinuses—Ethmoids

P A MACDONALD, M Sc, Ph D, Winnipeg Radiation Standards and Their Practical Application

DR RICHARD PROCTOR, Edmonton Treatment of Hodgkin's Disease from a Radiological Viewpoint

DR H H MURPHY, Victoria Epiphysitis

Thursday, June 21

DR GEORGE H MALCOLMSON, Edmonton A Radiological Study of the Development of the Spine and Pathological Changes in the Intervertebral Discs

Symposium on the Relationship of the Radiologist to Some Phases of Medical Practice

(1) DR B J HARRISON, Vancouver Relationship of the Radiologist to the Hospital

(2) DR E E SHEPLEY, Saskatoon Standing of the Radiologist in the Treatment of Disease with Radium

(3) DR C W PROWD, Vancouver Relationship of the Radiologist to Public Organizations, *ie*, Health Insurance Boards, Workmen's Compensation Boards, etc

(4) DR C M HENRY, Regina Relationship of the Radiologist to the Profession Election of Sectional Officers and Business Meeting

Friday, June 22, 9 A M to 12 M

Dr Max Cutler, Chicago, will conduct a Cancer Clinic

## PROGRAM FOR ANNUAL MEETING

The Program Committee of the Section on Therapy invites papers from the membership-at-large in three Symposia for the annual meeting (1) Malignancy of the Mouth and Neck, (2) Breast and Pelvic Viscera, and (3) Dermatology

From present indications it would seem that it would be good policy to limit the number of papers to four in each session. This would make a total of twelve papers. Up to the date of this announcement, three papers have been offered—two on Mouth and Neck conditions and one on Pelvic Viscera

In case more papers are received than can be accepted, the undersigned suggests that all papers be submitted to the Advisory Program Committee for selection, and those not accepted be referred to the Editor for publication in the Journal, with whatever corrections are necessary, and at such time as space may be found available

A good and well-balanced program is the most essential feature of a scientific meeting. This can be secured only by early co-operation from the essayists. Please act accordingly

ALBERT SOILAND, M D  
For Section on Therapy

# ABSTRACTS OF CURRENT LITERATURE

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H W HEFKE, M D, of Milwaukee	DAVIS H PARDOLL, M D, of Chicago
HANS A JARRE, M D, of Detroit	E A POHLE, M D, Ph D, of Madison, Wisconsin
E T LEDDI, M D, of Rochester, Minnesota	CHARLES G SUTHERLAND, M D, of Rochester, Minnesota

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## APPARATUS

Further Technical Improvement of the Body Cavity Tube and its Applicability W Schaefer and E Witte *Strahlentherapie*, 1934, XLIX, 298-303

The authors describe an improved model of their roentgen-ray tube which is constructed for use in body cavities (see "Strahlentherapie," 1932, XLIV, 283). It is necessary to ground the transformer on one end. They are now attempting to increase the tube potential from 100 to 180 kilovolts. Because of the short FSD it is possible to apply from 50,000 to 100,000 r per hour.

ERNST A POHLE, M D, Ph D

A New Apparatus for Ultra-short Wave Therapy Johannes Pätzold *Strahlentherapie*, 1934, XLIX, 345-350

A new apparatus is described for treatment with electrical waves from 7 to 3.25 meters in length. The apparatus and also the circuit are shown in the illustrations.

ERNST A POHLE, M D, Ph D

A Tube with Rotating Anode and Radiation-cooling at High Temperature Alfred Ungelenk *Fortschr a d Geb d Röntgenstr*, 1934, XLIX, 102-170

The tube factory of the Siemens Reiniger concern has constructed a new high capacity tube with rotating tungsten target. This is formed as a disc of about 60 cm surface, shaped to give a line-focus effect with a proper cathode and eliminating heat by radiation like the standard Coolidge tubes. The target stem is mounted on ball bearings. The capacity is 28 K W for 0.05 sec, 24 K W for 0.1 sec, 10 K W for 1 sec, 3 K W for 5 sec, 47 rev/sec. The tube can be mounted in shock- and radiation proof shields of the common Siemens type and be used for fluoroscopy and radiography.

HANS A JARRE, M D

## BONES, ABNORMALITIES

Some Further Observations on Post-traumatic Paramalleolar Ossifications, with Special Regard to Their Differential Diagnosis from Fractures Stefano Bistolfi *Archivio di Radiologia*, 1933, XII, Nos 5 and 6, pp 1061-1081

The author points out the radiologic aspects of this lesion as observed in two cases which may be important from a clinical and medico-legal point of view.

E T LEDDY, M D

The Os Acromiale and Its Differential Diagnosis Fritz Becker *Fortschr a d Geb d Röntgenstr*, 1934, XLIX, 135-142

The os acromiale is a persistent epiphysis of the acromion scapulae. A survey of 240 shoulders showed this ossicle in 6.6 per cent. It is usually shown only in axial views of the shoulder and may occur on one or both sides equally often and in a variety of configurations, as it develops from two to five centers of ossification. Differential diagnosis between this anomaly and fracture is often difficult. Pseudo-arthroses occur. For differentiation one has to consider ossification due to peri arthritis humero-scapularis, following dislocations or other trauma, in subdeltoid bursitis, 'joint mice,' etc. Cases of arthritis deformans inter-acromialis are shown and a questionable case of "os glenoidale" is reported.

HANS A JARRE, M D

A Study of Sprengel's Deformity Cesare Fava *Archivio di Radiologia*, XII, Nos 5 and 6, pp 1024-1036

The author describes a case of Sprengel's deformity (congenital upward displacement of the scapula) in a baby of eleven months, with some new bone formation between the scapula and the spine, accompanied by rickets. Fava offers as an explanation for the occurrence of the lesion that small bony nuclei may have become detached from the scapula or vertebrae during fetal life and developed in a muscular enclosure.

E T LEDDY, M D

## BONE DISEASES (DIAGNOSIS)

Familial Neurotrophic Osseous Atrophy A Familial Neurotrophic Condition of the Feet, with Anesthesia and Loss of Bone E Maurice Smith Jour Am Med Assn, Feb 24, 1934, CII 593-595

An unusual condition is reported, which has not permitted classification, has been observed in two generations of a family and has a definite history in a third earlier generation

Microscopic examination of nasal smears and biopsy material from the lesions on the feet have been negative for acid fast bacilli The Wassermann reaction is negative for syphilis in all but one case Tuberculosis and syringomyelia are readily eliminated on clinical grounds Leprosy has been given serious consideration but was excluded because of the absence of manifestations elsewhere than on the feet and the uniformity of the type of manifestations in all members of the group

CHARLES G SUTHERLAND, M D

## THE BRAIN

Cerebral Cysts Winchell McK Craig and James W Kernohan Jour Am Med Assn, Jan 6, 1934, CII, 5-11

Between 10 and 15 per cent of the surgical conditions of the brain were found to be cystic This particular group of conditions involving the cerebral hemispheres has been divided into congenital, inflammatory, traumatic, parasitic, and neoplastic types Congenital cysts may be subdivided into porencephalic, epidermoid, and simple Porencephalic cysts either communicate with the subarachnoid space and the ventricle, or extend so deeply into the brain that they cause distortion of the ventricular outline The walls of epidermoid cysts are lined with epithelium in which there are few glandular structures and the contents are not fluid, but caseous Simple cysts are subcortical cavities containing clear fluid, with no evidences of neoplasm or inflammation

Inflammatory cysts are rare and consist either of collections of fluid in the chronically inflamed pial space or subcortical collections of fluid associated with chronic cephalitis

Traumatic cysts may be divided into subdural hematomas, calcified and simple cysts Subdural hematomas occur between the dura mater and the cortex of the cerebrum Calcified cysts are frequently the result of a subcortical hematoma, and are encountered at an age when spontaneous hemorrhages are not likely to occur Smooth walled cysts have been encountered following a definite history of trauma, these contain clear fluid and there is no evidence of neoplasm in their walls

The most common parasitic cysts are the echinococcus, these may be solitary and frequently contain daughter and granddaughter cysts and may occur subcortically, or they may be attached to the meninges

The neoplastic cyst is by far the most common type encountered at operation Almost all types of tumor

have been found associated with cysts, the more benign and slow growing types seem to have a greater tendency to degenerate and form cysts than the more rapidly growing ones

A less important group of cysts, encountered among elderly patients, comprises those associated with arteriosclerosis They are liquefied infarcts in which absorption of the debris has been completed, and contain clear fluid Blood pigment is often found in the walls of these cavities

Case reports with roentgenographic and ventriculographic findings are given in detail

CHARLES G SUTHERLAND, M D

## CANCER (DIAGNOSIS)

Development of Carcinoma in Fistulas of Chronic Osteomyelitis Hans Hellner Fortschr a d Geb d Röntgenstr, 1934, XLIX 109-117

Development of carcinoma in a chronic osteomyelitic fistula or in tuberculosis of bone is rare Three cases are reported, which developed after years of chronic discharging sinuses Roentgenograms show a quickly progressive rarefaction in the sclerotic bone surrounding the sinus Clinically, exacerbation of pain, with increase of a foul discharge, are arousing suspicion. Early histologic examination of curettings are essential Chronic inflammatory disturbance of epithelial regeneration is regarded as responsible for the genesis of the malignant degeneration Early amputation is advisable

HANS A JARRE, M D

## CANCER (THERAPY)

The Influence of Syphilis on the Radiosusceptibility in Radium Therapy of Uterine Carcinoma H O Kleme Strahlentherapie, 1934 XLIX, 415-421

The author analyzed the histories of 20 patients who received radium therapy for carcinoma of the cervix and 2 patients treated for carcinoma of the fundus In all 22 patients, the diagnosis of syphilis was made beyond doubt It appeared that this type of case is apt to develop injuries of the bladder and colon, often leading to fistula The author believes therefore, that patients with syphilis are more susceptible to irradiation and recommends that the technic of application should take cognizance of this fact

ERNST A POHLER, M D, Ph D

Cancer Therapy with Lightly Filtered Radium P Feldweg Strahlentherapie, 1934 XLIX, 291-297

The author compared the surface and depth doses of radon screens filtered through 0.2 Ag + 1.0 Al and through 0.2 Ag + 1.0 Br He found that with the Ag-Al screen the dose at 2 cm distance was 375 r in 24

hours, with the Ag-Br screen it was only 348 r in 24 hours. Since at the same time with the heavier filter the surface dose is very high, the author used the Ag-Al screen in 120 cases of intra-uterine applications. During four years' observation this method has appeared to be entirely without danger, and, therefore, he recommends this technic.

ERNST A. POHLE, M D, Ph D

Tumor of the Granuloma Type in the Chest Georg Steiner *Strahlentherapie*, 1934, XLIX, 351-356

The author relates the history of a woman 48 years of age, seen in 1929, with a large mediastinal tumor suggestive of Hodgkin's disease. There was no enlargement of lymph glands or spleen. Technic of treatment: 175 K V, 0.5 Zn + 2 Al, 2 anterior and 1 posterior field of 20 × 20 cm, at 30 cm FSD, 55 per cent ED over each area. Two months later a second series was given and 5½ months later a third series. The tumor disappeared, the patient gained weight, and early in 1930 a fourth prophylactic series of treatments was given. A recurrence in the right upper lobe developed in July, 1931, which was treated. In July, 1932, a very small supraclavicular gland was palpated, excised, and the diagnosis of lymphoblastoma made. There had been no recurrence in the mediastinum at the time of publishing the report.

ERNST A. POHLE, M D, Ph D

The Prognosis in Adenocarcinoma of the Breast Treated by Irradiation J. Borak. *Strahlentherapie*, 1934, XLIX, 263-290

During the period 1928-1932 the author saw 17 cases of adenocarcinoma of the breast. The average period between the appearance of the first symptoms and the beginning of radiation therapy was two years, the average duration of life 41 months. A careful analysis of the entire material leads him to the conclusion that adenocarcinoma of the breast cannot be cured by irradiation. Even large doses which, however, do not cause necrosis of the connective tissue do not remove the tumor entirely. This radioresistance is in accord with the behavior of normal breast glands, which also cannot be completely destroyed unless doses are given which produce necrosis of the connective tissue.

ERNST A. POHLE, M D, Ph D

Results of Elective Therapy in Treating Carcinoma of the Cervix F. v. Mikulicz-Radecki *Strahlentherapie*, 1934, XLIX, 407-414

After a discussion of the principles governing statistics for comparing the results of operation and irradiation in carcinoma of the cervix uteri, the author publishes his experience with the "elective" therapy. He

defines this as follows: Very early cases are operated on and all others are treated by x-ray plus radium. From a study of the average data he concludes that elective therapy increases the 5-year cures by 40 per cent. He does not accept, therefore, the statement that irradiation and operation offer the patients with early carcinoma of the cervix the same chance of permanent cure.

ERNST A. POHLE, M D, Ph D

Roentgen and Radium Treatment of Operable and Borderline Cases of Breast Cancer J. H. Douglas Webster *Strahlentherapie*, 1934, XLIX, 255

The author relates his experience in the treatment of 41 cases of carcinoma of the breast by radiation alone, and in 358 cases in which irradiation followed operation. His statistical studies show that the percentage of 5-year cures can be doubled by post-operative irradiation as compared with surgery alone. Pre-operative irradiation is urged in addition to treatment after operation. The 5-year cure in 41 patients treated by irradiation alone was 66 per cent. Induration of the lungs due to the treatment can be avoided by proper technic.

ERNST A. POHLE, M D, Ph D

## CONTRAST MEDIA

Demonstration of the Maxillary Sinus, Epipharynx, and the Trachea with Contrast Medium A. Zuppinger and L. Rüedi *Fortschr. a. d. Geb. d. Röntgenstr.*, 1934, XLIX, 176-190

Lipiodol-filling of the maxillary antra is best obtained by puncture from the middle nasal meatus and shows well the capacity of this cavity and condition of its mucosa. It is indicated in all doubtful affections of the maxilla, especially neoplasms of the palate and alveolar process, of the nasal passages, etc., including cases lacking clinical symptoms referable to the antrum.

The epipharynx is easily demonstrated with lipiodol if views in submental-axial and lateral projections are secured on the overhanging head. All types of encroachment on its lumen are readily shown.

Demonstration of the trachea is easily accomplished after lipiodol injection into the larynx. Reliable conclusions can be drawn concerning course and lumen of this tube.

HANS A. JARRE, M D

## DIABETES MELLITUS

A Clinical Contribution to the Question of the Value of Roentgentherapy of the Hypophysis in Diabetes Mellitus. The Effect of Irradiation on the Hydrocarbon Level and on the Blood Picture Nicola Tucci *Arch. di Radiologia*, 1933, XI, Fasc. 3, pp. 481-528



Four cases of diabetes mellitus (in three of which the disease was pancreatic and all chance of pituitary or tubero-hypophyseal dysfunction was excluded) were treated by the method of Boschi, namely, irradiation of the pituitary through temporal fields. No result was obtained, so that Fucci contends that the idea of Vespignani that all cases of diabetes should be similarly treated (by Boschi's method) is untenable. From his study of the effects on the blood, Fucci concludes that they are an expression of a hypersympathetico-tonic syndrome from an effect on the vegetative nervous system.

E T LEDDA, M D

## DOSAGE

Dosimetry in Superficial Therapy. F Bodecker. *Strahlentherapie*, 1933, XLVII, 100-110.

The author gives a number of tables showing the relation between doses expressed in X and in r. Half value layers are given both for water and aluminum. The doses recommended by Meyer in the treatment of skin conditions are also tabulated, they are modernized and give all doses in r units.

ERNST A POHLE, M D, Ph D

The Measurement of High Roentgen ray Intensities with the Integrating Small Chamber Dosimeter. Gottfried Spiegler. *Strahlentherapie*, 1934, XLIX, 304-308.

The author found that an integrating dosimeter equipped with the thimble type of ionization chamber does not measure high intensities accurately. He used the inverse square law in making his tests. For 60 r per minute the error amounted to 10 per cent. Although he does not wish to discredit the ionization method for determining the dose in x ray therapy, he feels that each instrument should be more thoroughly tested by the factory and its limitations stated.

ERNST A POHLE, M D, Ph D

## EXPERIMENTAL STUDIES

The Mechanism and the Value of Roentgentherapy in Small Doses in Puerperal Mastitis. G J Pfalz. *Strahlentherapie*, 1934, XLIX, 357-406.

The considerable number of patients with puerperal mastitis induced the author to study experimentally and clinically the possibility of using roentgen rays as a therapeutic agent. Mastitis was produced in guinea pigs experimentally by injection of *Staphylococcus hemolyticus aureus* into the breast. The roentgen doses amounted to 320 r (180 K V, 0.8 mm Cu, 36.5 F D). By producing bilateral mastitis and treating only one side, the author could show that irradiation therapy is of definite value. The changes of the blood immunity were studied by determining the opsonic

and leukocytic index with the technic of Wright. Both were found to be increased when early stages of the mastitis were subjected to irradiation. A reaction favorable for an early healing of the inflammatory process was also seen by studies of the leukocytes. The quality of radiation had no influence on the effect. Doses under or over from 300 to 400 r were of no benefit in guinea pigs. In human therapy, the fields were 10 X 15 cm at 40 cm FSD and a single dose of from 50 to 60 r was applied. The results obtained in the treatment of 41 cases were so encouraging that the author recommends his method.

ERNST A POHLE, M D, Ph D

## THE EYE (THERAPY)

Roentgen Therapy of Absolute Glaucoma. P Hess. *Strahlentherapie*, 1934, XLIX, 422-426.

The author treated 15 cases of glaucoma with roentgen rays, using the following technic: 500 r in one sitting over an anterior and a temporal field with a half value layer in Cu = 0.85 mm, field size 4 X 4 centimeters. The dose effective in the diseased tissue should amount then to approximately 800 r. Within from 4 to 6 weeks the pain usually disappeared. It is essential that one shall use the dose recommended, since lower doses do not bring about relief. In 9 cases out of 12 with idiopathic glaucoma, radiation therapy was successful. One did not respond because of insufficient dosage, two eyes had to be removed later because of ulceration. One out of three cases of secondary glaucoma was considerably improved, two had to be operated on for cosmetic reasons.

ERNST A POHLE, M D, Ph D

## FRACTURES

The Technic of Demonstrating the Nasal Skeleton in Roentgenograms. S Grauer. *Röntgenpraxis*, August, 1933, V, 607-610.

For good reduction of the fragments of a fracture of the nasal skeleton, knowledge of the position of the fragments is necessary, and lateral roentgenograms of the nose have been used to get such information. The author suggests a new technic in addition, that is, a vertical direction of the central ray in the fronto-maxillary direction. A large dental film (4 X 5 cm) is put into the patient's mouth so that it extrudes for about 3 centimeters. The central ray is tangential to the frontal bone. The proximal third of the nasal bones often cannot be shown, but is usually not involved in the fracture.

H W HEFKE, M D

## GENITO-URINARY TRACT (DIAGNOSIS)

Routine Use of Neoskoldan in Suspected Injuries to the Genito-urinary Tract. Charles M McKenna. *Jour Am Med Assn*, Feb 24 1934, CII, 599-602.

Excretory urography is a valuable asset, not only in a positive but also in a negative finding, in the early diagnosis of what is commonly referred to as internal injuries from trauma. A flat roentgenogram should first be made. In industrial surgery it is important to know whether or not the urinary tract is involved in the injury. In suspected trauma of the kidney itself, the use of intravenous urography is left to the discretion of the surgeon in charge of the injured patient. If used, it is informative as to whether the rupture is within the kidney, has extended through the true capsule, or invaded the peritoneal cavity. If extraperitoneal with a small amount of extravasation, watchful waiting and subsequent checking for any increase in size of the extravasation is the best procedure. If intraperitoneal, immediate surgical intervention is indicated.

Information regarding the condition of the opposite kidney has been made available by the excretory urogram. Rupture of the ureter may be complete or incomplete. Excretion urography will determine whether a rupture of the bladder is intra- or extraperitoneal, accurately locate the rent, and demonstrate the extent of the extravasation.

CHARLES G. SUTHERLAND, M.D.

## GRENZ RAYS

New Possibilities for Grenz-ray Therapy Julius Samel. *Strahlentherapie*, 1934, XLIX, 536-540.

It is possible to desensitize the human skin against artificial eczemas by exposure to Grenz rays. A total dose of 2,000 r (H.V.L. in Al of 0.03 mm.), applied in daily doses of 200 r, is sufficient. This resistance develops from three to four weeks after irradiation, and lasts for a period of from eight to ten weeks. The author bases a modification of his technic in certain skin diseases on this observation. For acne vulgaris, he uses single doses of from 100 to 200 r, up to total doses of from 1,000 to 2,000 r. Twice a week, in acne rosacea, he gives 150 r each up to a total dose of 2,000 r. A similar technic is of benefit in pruritus ani et vulvæ and lichen ruber planus. As a supplementary treatment method, Grenz rays in doses of from 50 to 100 r can be of value in the acute stage of eczema.

ERNST A. POMER, M.D., Ph.D.

## GYNECOLOGY AND OBSTETRICS

Clinical Significance of Roentgenometry in Obstetrics Herbert Thoms. *Jour Am Med Assn*, Feb 24, 1934, CII, 602, 603.

External pelvimetry fails to give uniformly accurate information as to the size and shape of the superior strait. This is especially true in certain thin, undersized individuals. Although external pelvic measurements suggested a generalized pelvic contraction, roentgenograms disclosed a relatively capacious pelvis. Conversely, many thick boned, short, squatty indi-

viduals with similar external measurements showed contracted pelves. In a relatively large group the length of the transverse diameter was so shortened as to equal that of the anteroposterior diameter. Because of the apparent relationship between a shortening of the transverse diameter and a primary or transient, and a secondary or persistent, occipitoposterior presentation, accurate information regarding the length of this diameter is of clinical importance.

If the patient is placed in a supine position, a roentgenogram of the fetal head *in utero* provides an easy method of measuring the occipitofrontal diameter, and a useful means of computing the biparietal diameter. The length of the occipitofrontal diameter may be used in determining the maturity of the fetus *in utero*.

Roentgen pelvimetry has a distinct place in the examination of every primiparous woman. It is important in the diagnosis of fetal position, the presence of fetal abnormalities, the presence of multiple pregnancy, and perhaps more especially in the diagnosis of a rachitic deformity of the sacrum.

CHARLES G. SUTHERLAND, M.D.

## HEART AND VASCULAR SYSTEM

The Roentgen Diagnosis of Cardiac Aneurysms David Steel. *Jour Am Med Assn*, Feb 10, 1934, CII, 432-436.

Relatively few cases have been recognized clinically. A still smaller number have been recognized roentgenologically, because they often do not produce any change in the silhouette. Usually the lesion is single, but several aneurysms can be present in one patient. Kraus described three types: (1) Those of the right sinus of Valsalva, which perforate into the right ventricle, including (a) congenital and (b) acquired. The acquired include ulcerating processes near the sinus, developing subsequent to malignant endocarditis. (2) Intravalvar aneurysms in the sinus of Valsalva. (3) Partial cardiac aneurysms, for the most part due to coronary sclerosis. Pathologically, cardiac infarcts show no essential variation from similar lesions in other organs. They have a roughly triangular outline, with the base toward the endocardium and the apex toward the epicardium.

Aneurysm can be present and give no roentgen signs. When the lesion is well developed, it appears as a sharply defined bulging of the upper portion of the left ventricular silhouette. This bulging may amount to only a slight increase in the curving of this portion of the ventricle, but it can be so well marked that an incisura is formed between it and the lower or normal portion of the ventricle. In either case the radius for the upper or aneurysmal portion is smaller than the radius for the lower or non aneurysmal portion. Careful examination of the pulsating phenomenon early in the course of the disease might give supporting or actual diagnostic evidence.

CHARLES G. SUTHERLAND, M.D.

The Roentgen Demonstration of Calcified Coronary Arteries in Living Subjects Paul H Wosika and Merrill C Sosman Jour Am Med Assn, Feb 24, 1934, CII, 591-593

A fairly large amount of calcium is required to interrupt enough rays to cast a shadow that can be recognized. Fluoroscopic examination, looking through the cardiac shadow rather than at the movement of the heart borders, reveals calcium deposits in the coronary sulcus. These are best seen in the anterior oblique position, but the patient should be rotated in all directions. The shadow cast is quite close to the heart border, apparently just under the pericardium. Differentiation from valvular calcification is discussed in detail. The appearance of the calcified arteries on films also is characteristic. The shadows appear linear and segmental and are curved, corresponding to the course of the artery. Other areas to be differentiated from calcified coronary arteries are (1) pericardial calcification, (2) calcified costal cartilages, (3) bronchi behind the heart, and (4) calcified lymph nodes or nodules.

CHARLES G SUTHERLAND, M D

## HEMORRHAGE

Severe Hemorrhage into the Bladder Discussion of Such Hemorrhages and Case Report of an Unusual and Almost Fatal Hemorrhage. Montague L Boyd. Am Jour Surg, November, 1933, XXII, 203-206

Sudden, severe hemorrhages into the unopened bladder are usually best treated by emptying the bladder of clots through suitable urethral instruments, and then using quite hot bladder irrigations. Electrocoagulation of the bleeding points is, however, sometimes necessary, and occasionally even suprapubic cystotomy. In old or anemic patients radical measures should be instituted without too much delay when the hemorrhage is not readily controlled, especially if ample facilities for blood transfusions are not available for immediate use.

DAVIS H PARDOLL, M.D

## THE HIP JOINT

Early Diagnosis and Treatment of Congenital Dislocation of the Hip Joseph A Freiberg Jour Am Med Assn Jan 13, 1934 CII, 89-93

Three anatomic abnormalities exist in varying degrees in all congenital dislocation of the hip: unusual obliquity of the acetabular roof, annular constriction of the abnormally elongated capsule, and anteversion or antetorsion of the femoral neck.

In small infants the superior femoral epiphysis may not appear in the roentgenogram but the break in the normally symmetrical obturator-coxo-femoral line is seen up to six months of age, and sometimes until the walking period, the dislocated femoral head lies lateral

to the acetabulum and level with the superior margin of the acetabulum. A roentgen examination does not elicit abnormalities until the child is approximately five months of age.

In infancy, reduction is easily accomplished by closed or manipulative methods. Open reduction is indicated in a very small percentage of cases in which closed reduction is unsuccessful. The original manipulative reduction of Pacci is still the most satisfactory method in infants more than six months of age.

CHARLES G SUTHERLAND, M D

## PEPTIC ULCER (DIAGNOSIS)

Roentgen Evidence of Healing in Duodenal Ulcer Daniel M Clark and Milton J Geyman Jour Am Med Assn, Jan 13, 1934, CII, 107-112

The niche is the only pathognomonic roentgen evidence of an active peptic ulcer. Healing can be observed only in those instances in which the niche is seen and permanently recorded prior to the institution of treatment. Not over 10 per cent of duodenal ulcer niches are visible in film studies of the barium-filled bulb in the general run of cases. Berg, Akerlund, Albrecht, and others have developed a compression technic which permits accurate visualization and film recording in from 50 to 60 per cent of cases. From their own and others' experience they conclude that there is no fixed relation between niche disappearance and symptomatic relief and that niche disappearance does not simply complete healing. Contour deformities of the barium-filled bulb are of little or no value in determining the response of a lesion to treatment.

CHARLES G SUTHERLAND, M D

The Radiologic Diagnosis of Duodenal Ulcer in Children Marco Bermond Arch di Radiologia, 1933, XI, Fasc 3, pp 393-417

The author reports a case of duodenal ulcer in a 2-year-old child in whom the diagnosis was not confirmed operatively, but who recovered on medical treatment. The roentgen findings are essentially the same as are those in adults with the same lesion. Bermond thinks that duodenal ulcer should be ruled out by x-ray examination in the obscure cases of vomiting in childhood.

E T LEDDY, M D

## PERINEPHRITIC ABSCESS

Perinephritic Abscess Confused with Adjacent Osseous Lesions E E Kessler F A Bennetts, and S K. Bacon Am Jour Surg, November, 1933, XXII, 223-226

Pathologic processes presenting practically all the signs and symptoms of perinephritic abscess may be entirely outside the kidney fossa. Early accurate diag-

nosis in such cases with our present procedures is hardly to be expected. When surgical exploration for perinephritic abscess is unsuccessful a careful consideration and diagnostic investigation of all structures adjacent to the kidney should be made. Suppuration of structures other than the kidney and perinephritic fat in this region have the same etiologic background, *viz*, hematogenous infection from foci of suppuration elsewhere, and such cases occur with sufficient frequency to warrant their consideration in cases of suspected perinephritic abscess.

DAVIS H. PARDOLL, M D

### PHYSIOTHERAPY

Physiotherapy for Bronchial Asthma. G. Cola. *Archivio di Radiologia*, 1933, XI, No. 4, pp. 709-733.

Cola prefers roentgen irradiation of the thorax, of the chest and spleen, or of the hypophysis and irradiation with ultra violet of the chest and hypophysis for bronchial asthma in adults and in children. He thinks that treatment of the spleen alone is less valuable than the other methods. He then theorizes on the mechanism of the effect—a relief of the congestion of the bronchial mucosa, a destruction of the acidophile cells of the hypophysis, a tonic effect on the sympathetic nervous system, a desensitization of the body, a destruction of the tendency to anaphylaxis, and a re-establishment of the biocolloids.

E. T. LEDDY, M D

### RADIATION EFFECTS

Karyological Changes of the Seedlings of *Hordeum pallidum* Following Roentgen Exposure. W. P. Tschchow and N. N. Kartaschowa. *Strahlentherapie*, 1934, XLIX, 238-250.

Dry seeds of *Hordeum pallidum* were exposed to roentgen rays. In the first series 100 K V., 2 ma., and exposures beginning at 15 minutes and increasing by 5 minutes as high as 60 minutes were used. In the second series 70 K V., with maximum exposures of two hours were chosen. It appeared that roentgen exposure of dry seeds produces karyological changes in the seedling. This may be due either to a direct effect on the chromosomes during mitosis or an effect of the radiation on the nucleus at rest. From the results of the experiments it is also concluded that a direct effect of the roentgen rays on the chromosomes is not necessary for the production of karyological changes.

ERNST A. POHLE, M D, Ph D

carcinoma cells, both taken from tissue cultures, showed two absorption bands in 2,800 and 2,600 Å. There was a difference in absorption between smooth striped cells and heart muscle cells. Normal human skin has an absorption band at 2,600 Å which shifts to 2,800 Å following exposure to ultra-violet rays. This shift is explained by the formation of a protective substance.

ERNST A. POHLE, M D, Ph D

Experiments on *Drosophila melanogaster* Concerning the Relations between Dose and Application of Roentgen Rays and the Rate of Mutation. N. W. Timoféeff-Ressovsky. *Strahlentherapie*, 1934, XLIX, 463-478.

The rates of mutation produced by roentgen rays are directly proportional to the dose applied. An increase in the dose does not change the ratio between lethal and visible mutations. Subdivision of the dose has no influence on the mutation rate, and the quality of radiation is also of no influence. It appears likewise that the effect of radiation is independent of the temperature.

ERNST A. POHLE, M D, Ph D

The Mechanism of the Effect of Alpha Rays. F. Herčík. *Strahlentherapie*, 1934, XLIX, 438-450.

The author stated in a previous publication that it requires two alpha particles to kill a bacterium. Experiments carried out on *B. prodigiosus* verified the theoretical deductions. The findings agree well with Dessauer's "Punktwärme" theory.

ERNST A. POHLE, M D, Ph D

Changes in the Metabolism of Surviving Tissue Following Roentgen Exposure. A. Kahlstorf. *Strahlentherapie*, 1934, XLIX, 427-437.

The liver and testicles of adult white rats were exposed to roentgen rays (135 K V., 3 ma., 23 cm. FSD, 30 mm. Al, 14.8 sq. cm. field, 600 r measured in air, 10 min.). The animals were killed immediately after the exposure and the tissues of both organs prepared for study with the Warburg method. While there was a definite increase in the aerobic and anaerobic glycolysis, the oxygen consumption was definitely decreased.

ERNST A. POHLE, M D, Ph D

### ROENTGENKYMOGRAPHY

Pulsatory Movements of the Large Blood Vessels as Seen in Roentgenograms. Pleikart Stumpf. *Röntgenpraxis*, October, 1933, V, 721-732.

The movement of the large blood vessels coincident to pulsation may be shown roentgenographically best by the technique of kymography. When sphygmographic

Optic Studies on Tissue Cells. A. Smakula and H. Lauer. *Strahlentherapie*, 1934, XLIX, 489-497.

The absorption of various tissue cells was studied with the photo-electric method between 2,300 and 3,500 Å. Normal cells from connective tissue and

and roentgenkymographic examinations are done simultaneously, it becomes evident that the curves of motility of the vessels correspond with the well-known sphygmographic curves. For clinical use roentgenkymography is of importance, as it allows one to differentiate between fixed and moving shadows in the roentgenogram and between arterial and venous blood vessels. Characteristic kymographic curves are usually obtained in certain organic diseases of the circulatory apparatus (insufficiencies, stenoses, calcification, passive congestion, etc.). These advantages above those heretofore available through roentgenologic examinations indicate that roentgenkymography should be introduced as a routine examination for the diagnosis of changes in the large blood vessels.

H. W. HEFKE, M.D.

### SARCOMA

An Unusual Case of Ewing's Sarcoma. O. Spitzenberger. *Röntgenpraxis*, August, 1933, V, 590-594.

The first roentgenologically demonstrable changes in this case of Ewing's sarcoma could be shown about four weeks after the beginning of clinical symptoms, which consisted of pain and temperature. These roentgenologic changes were not characteristic and were slight irregularities of the cortex of the femur, which could not be differentiated from periostitis or osteomyelitis. (Clinical and roentgenologic symptoms do not allow a definite diagnosis of osteomyelitis or Ewing's sarcoma at an early stage of the disease.) Four weeks later there was marked progression of the disease, the roentgenologic findings being localization in the diaphysis, considerable extent of the process, marked

sieve-like destruction of the cortex, extensive cortical apposition of new bone, definite reaction to x-ray therapy, and the occurrence of metastases.

H. W. HEFKE, M.D.

### THE SKULL (DIAGNOSIS)

The Technic of Cerebral Arteriography. G. Bignami and G. Serra. *Archivio di Radiologia*, 1933, XII, Nos. 5 and 6, pp. 1006-1023.

The authors point out the value of studying radiologically various cerebral lesions after the injection of gaseous or opaque medium, and emphasize the advantages of encephalic arteriography. They then discuss the procedure as developed technically by various authors. Bignami and Serra favor iodomethansulphonate of sodium and discuss the technic of its use. The results they obtained are exemplified by several radiographic reproductions.

E. T. LEDDY, M.D.

Cerebral Angiography. Egas Moniz. *Archivio di Radiologia*, 1933, XI, No. 4, pp. 629-642.

Moniz describes his technic of injecting thorotrast into the common carotid artery to visualize the cerebral vascular system, and illustrates by radiographs some of the data brought out by this method of examination. He feels that this method furnishes valuable information in the localization of tumors and about the cerebral vascular system as a whole.

E. T. LEDDY, M.D.

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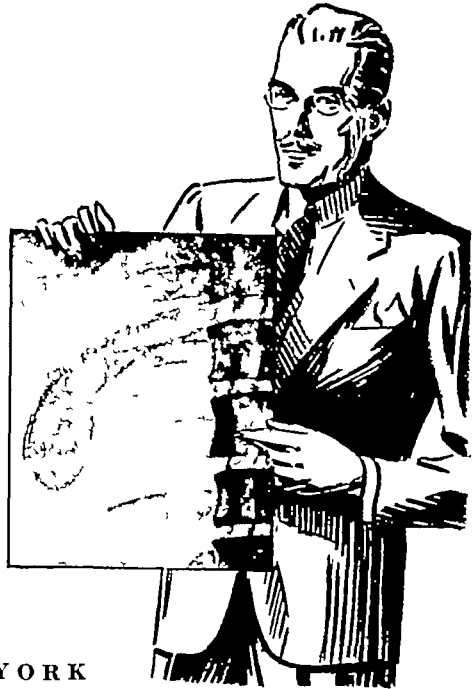
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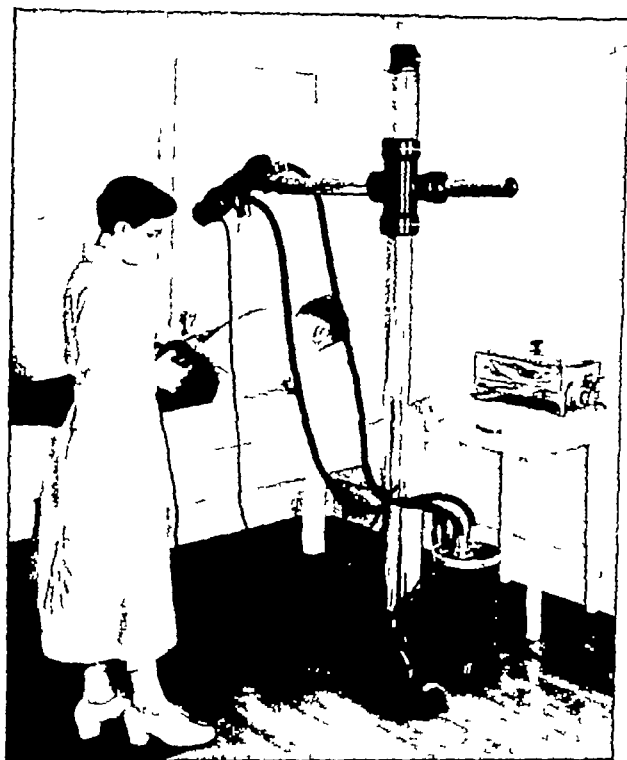
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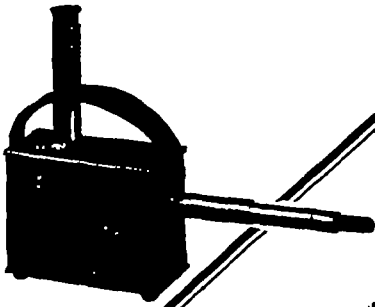
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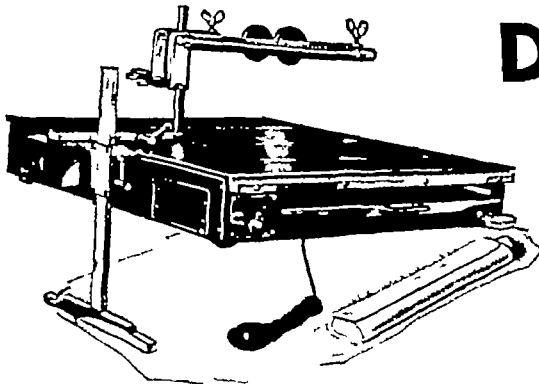
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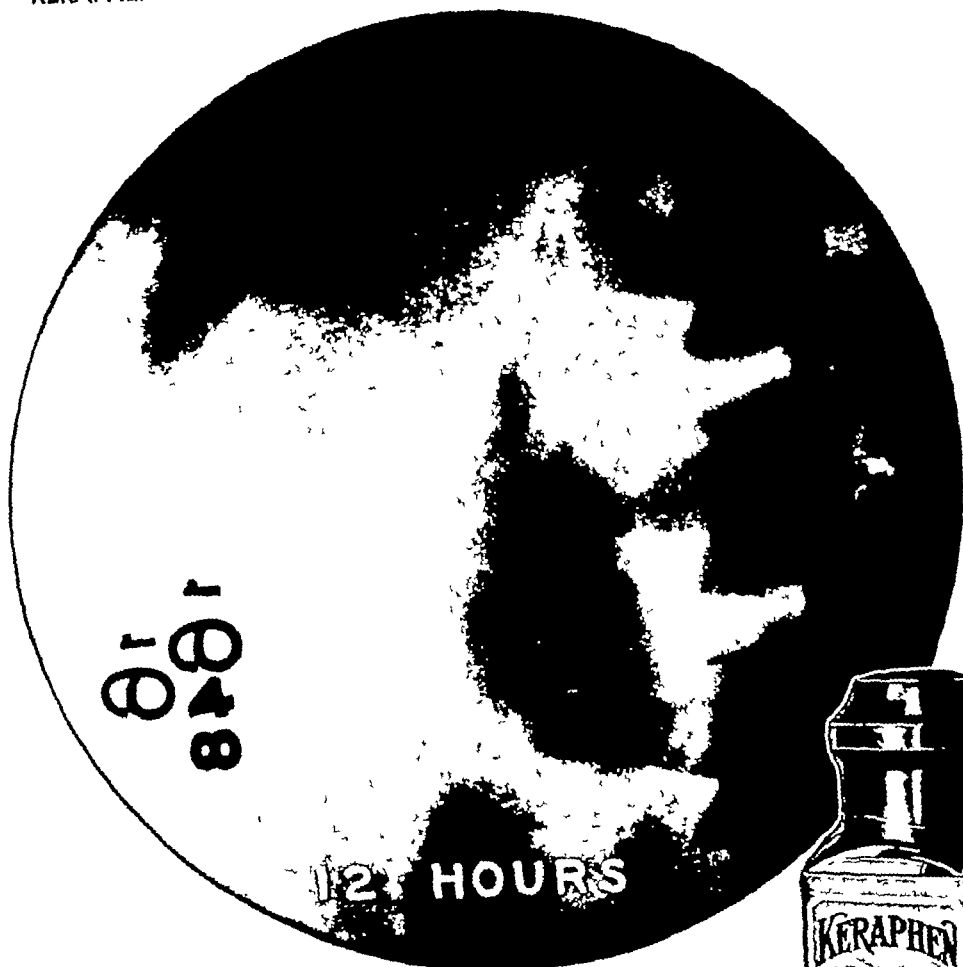
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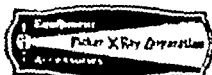
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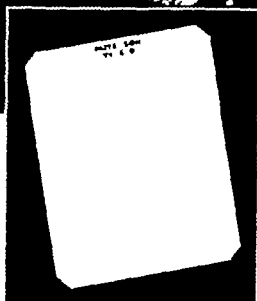
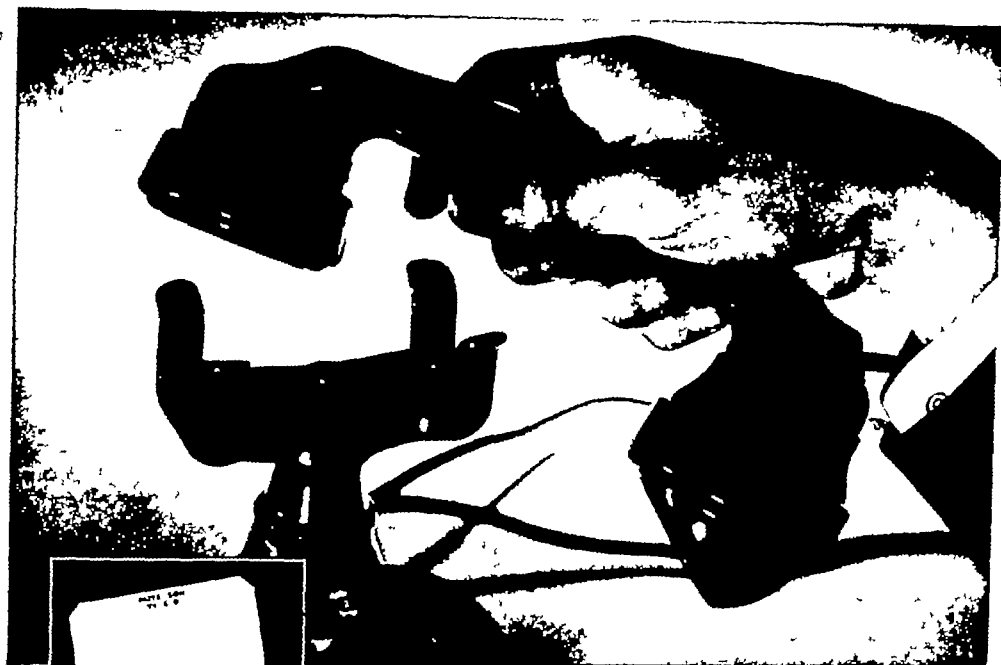
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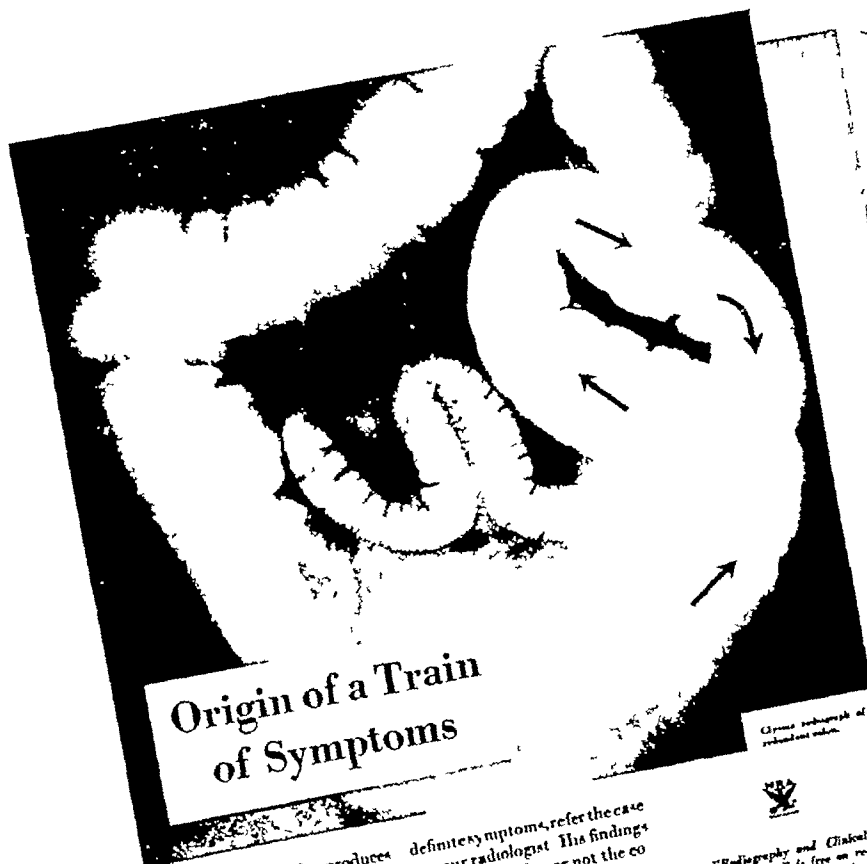
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